Landscape diversity, food-web interactions, and the rapid evolution of pea aphids to parasitism

NSF/NASA Dimensions of Biodiversity

2013-2018

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Jason P. Harmon, North Dakota State University
Kerry M. Oliver, University of Georgia
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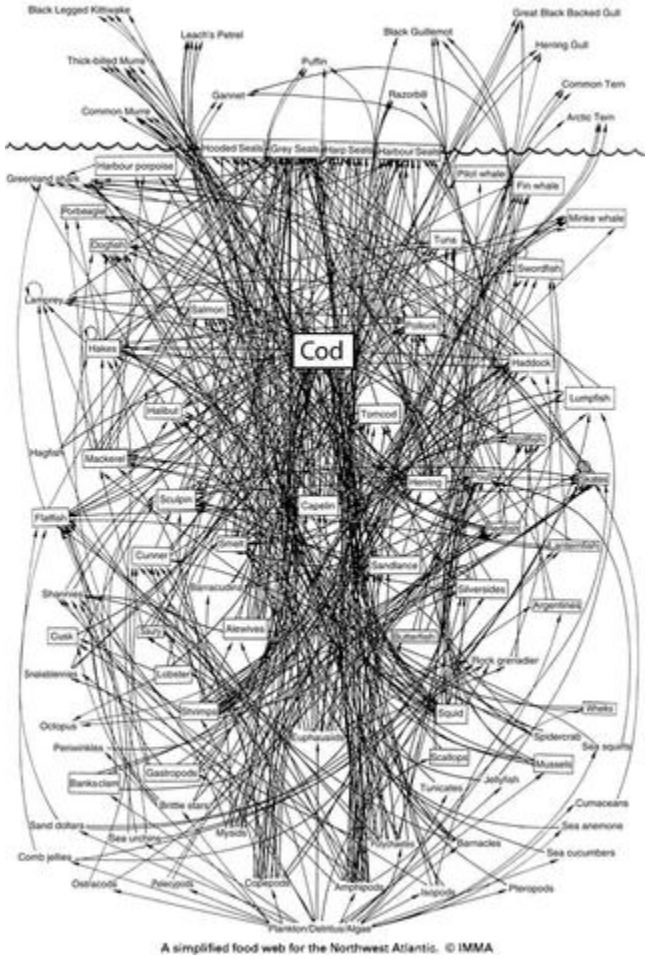
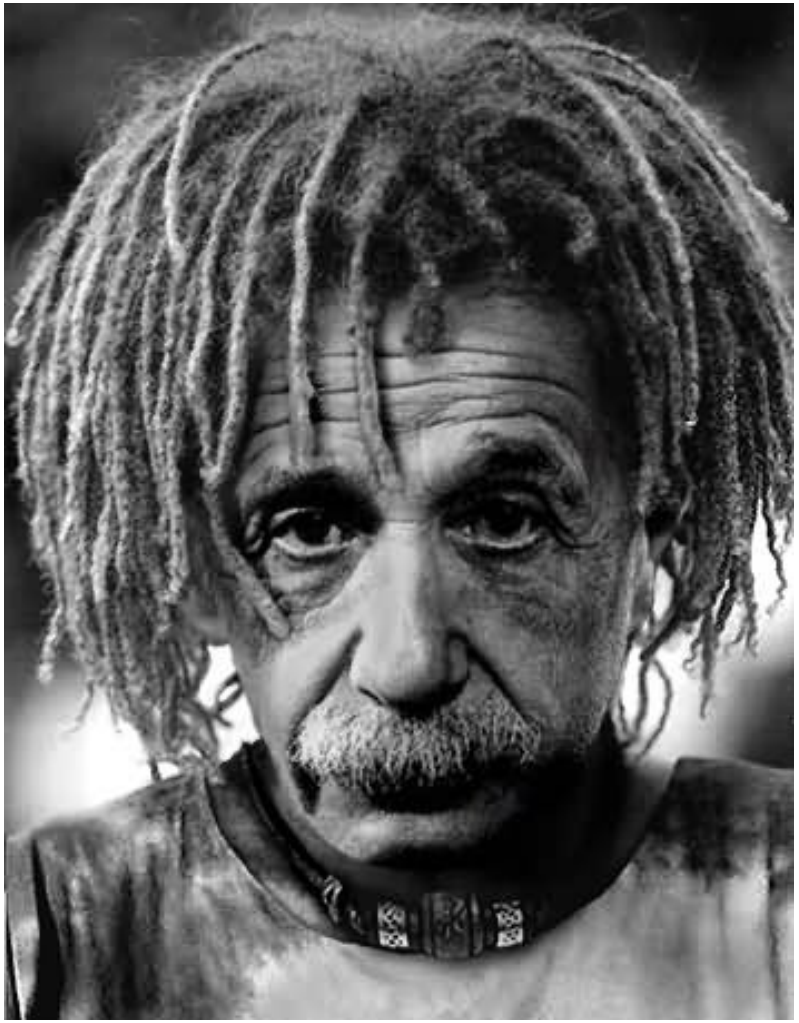
How does global change affect food webs?

Global change and food webs

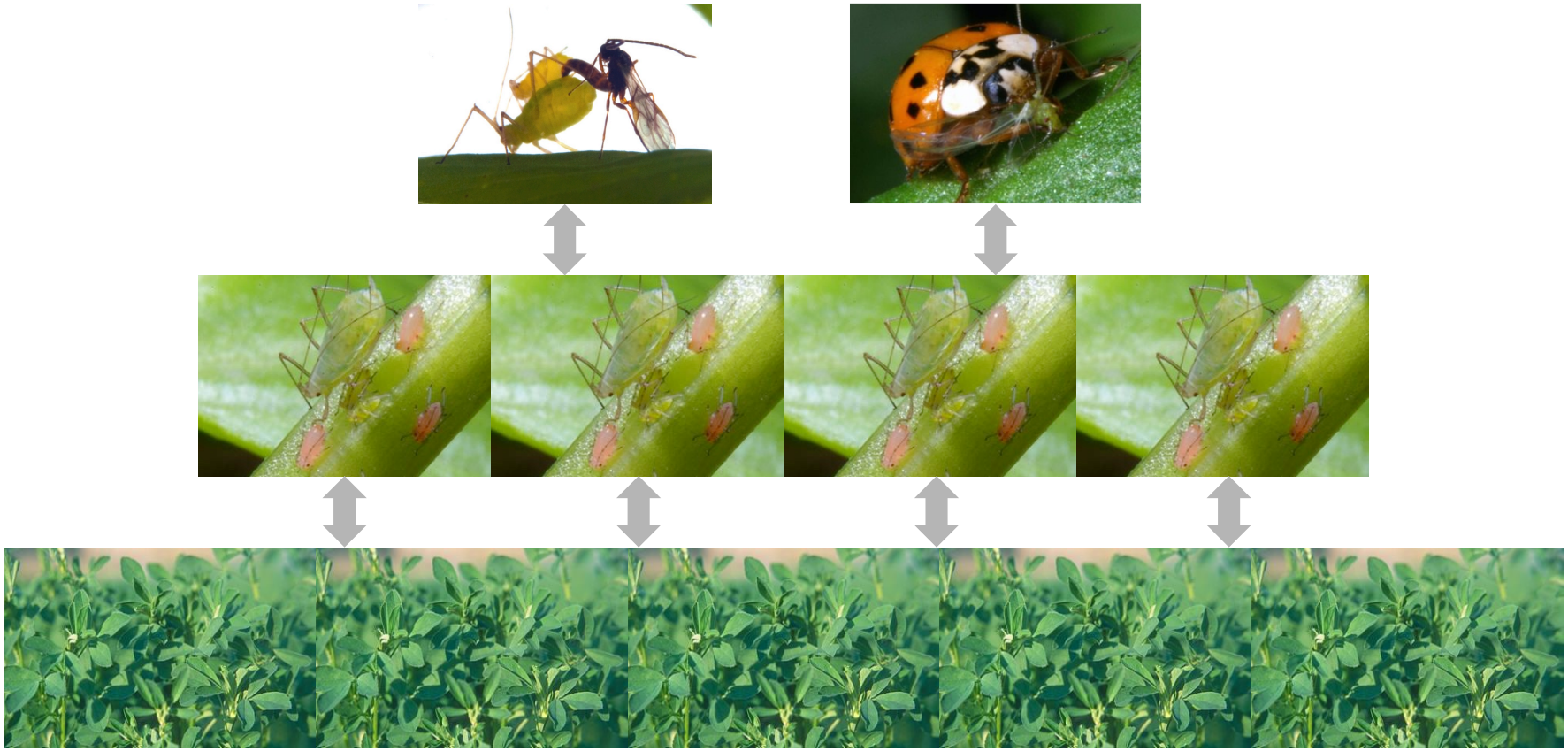


A simplified food web for the Northwest Atlantic. © IMMA

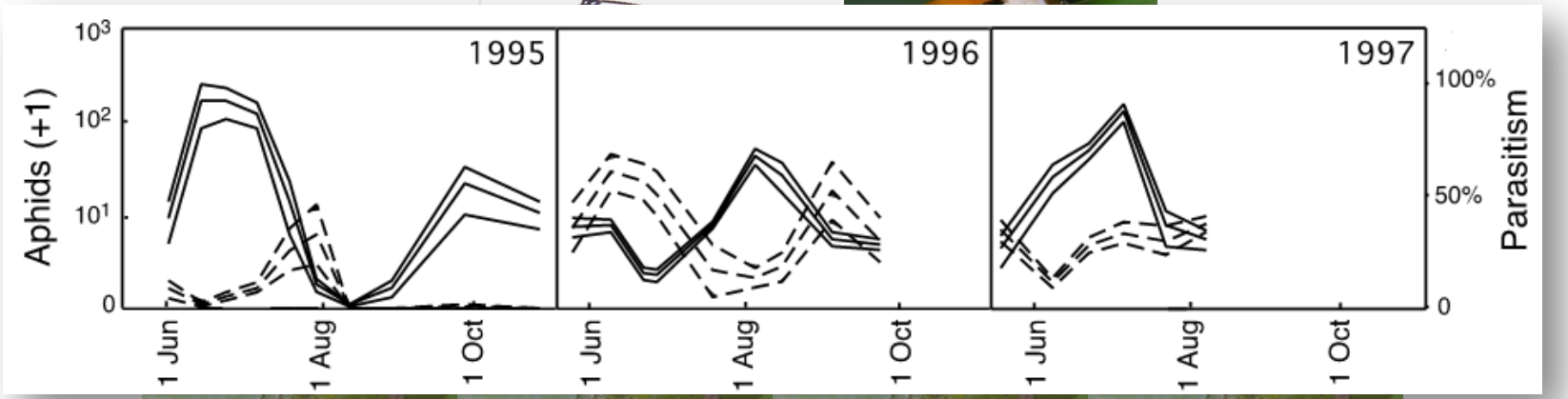
Global change and food webs

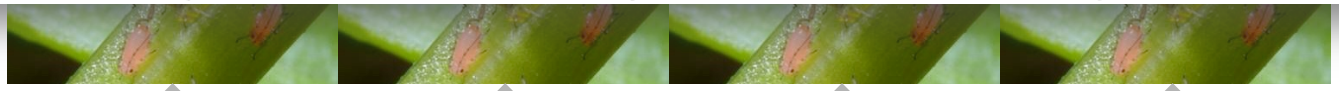


Global change and food webs



Global change and food webs





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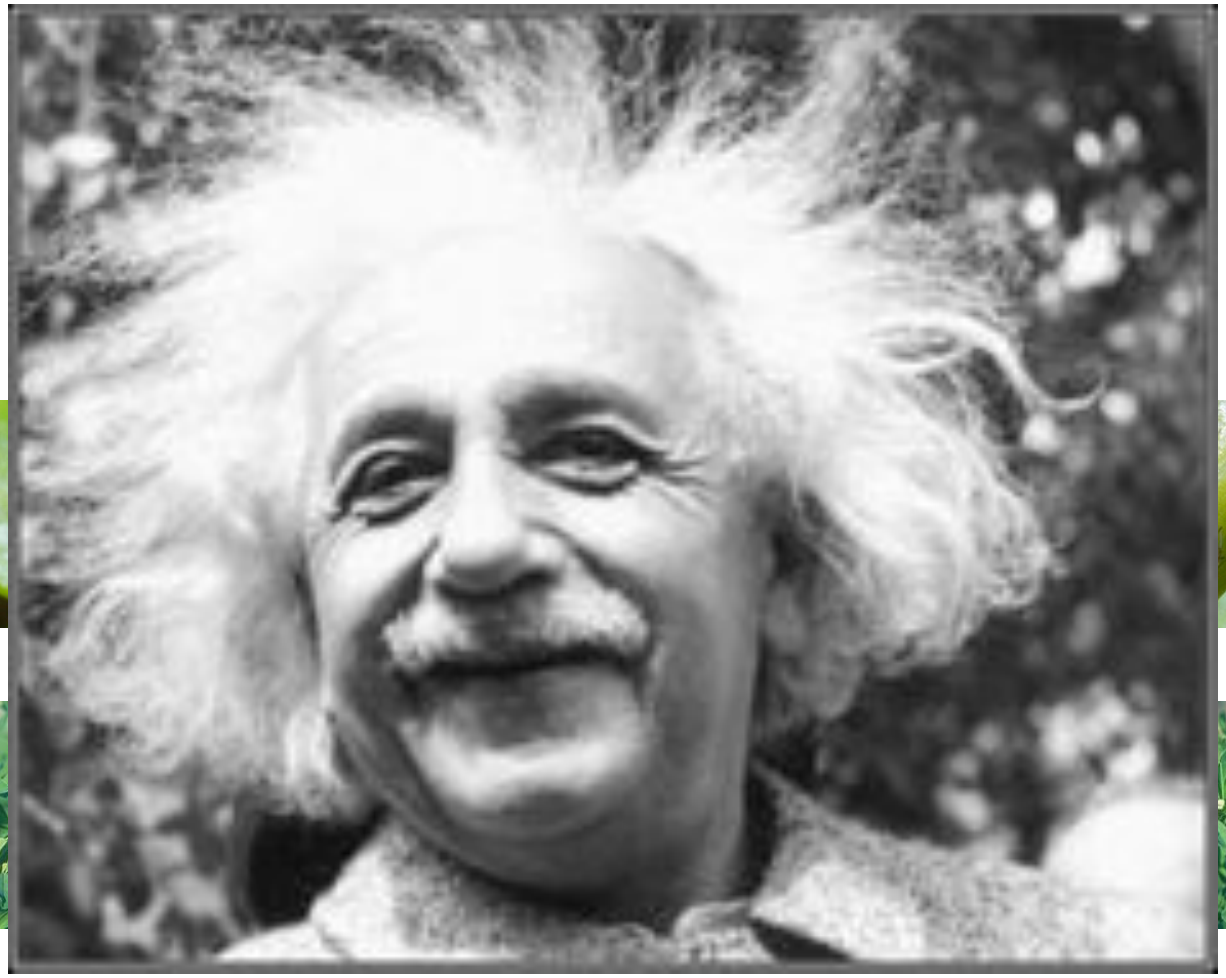
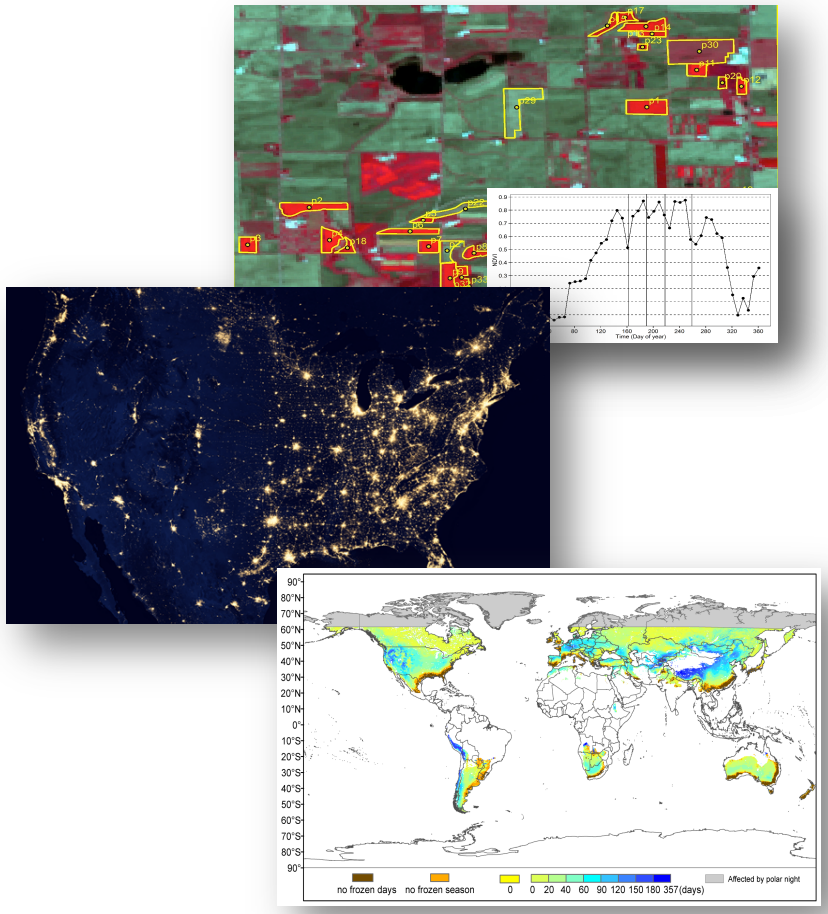


Global change and food webs

I. Landscape homogenization

II. Nighttime lights and warming

III. Global warming in winter

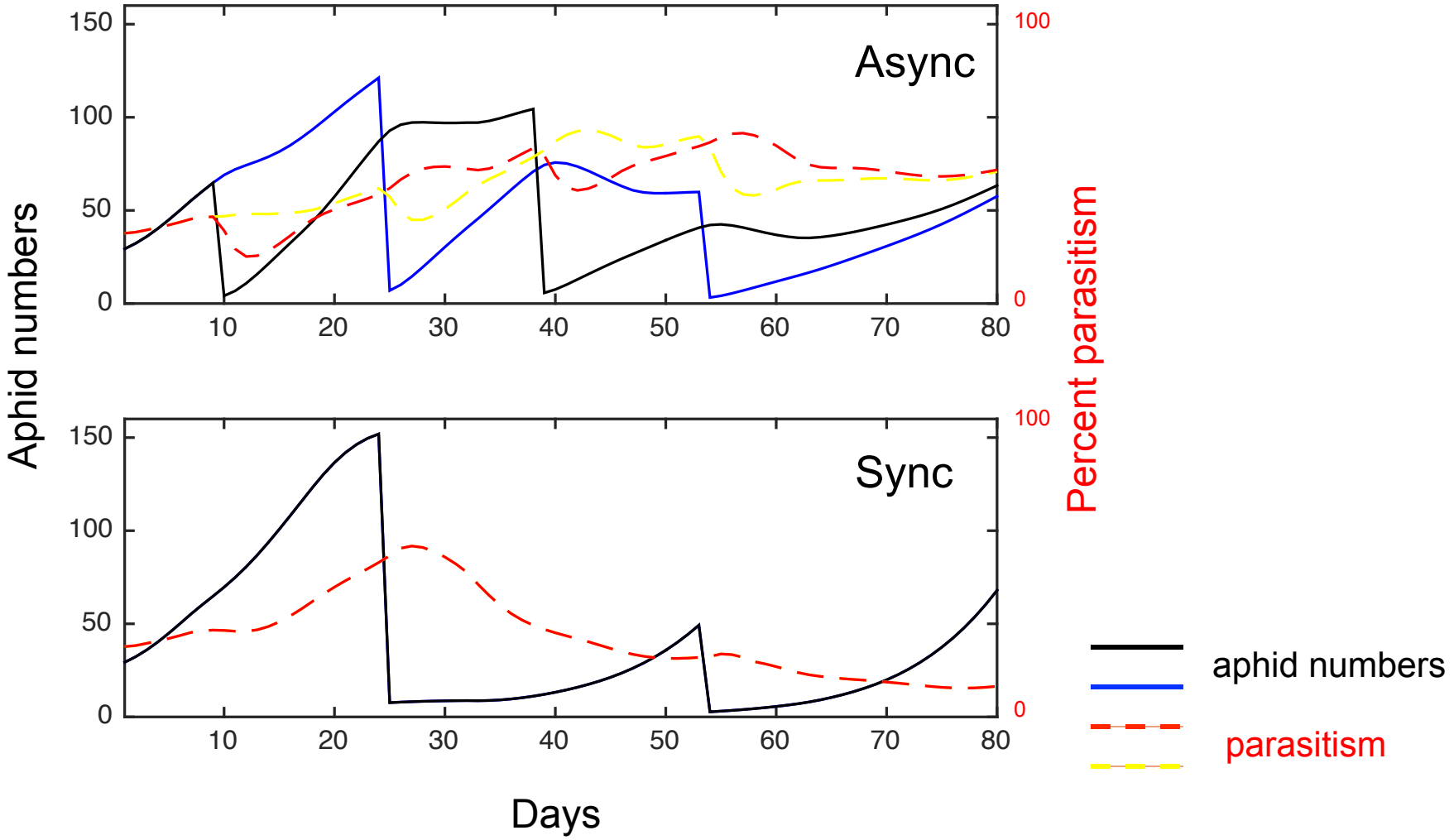


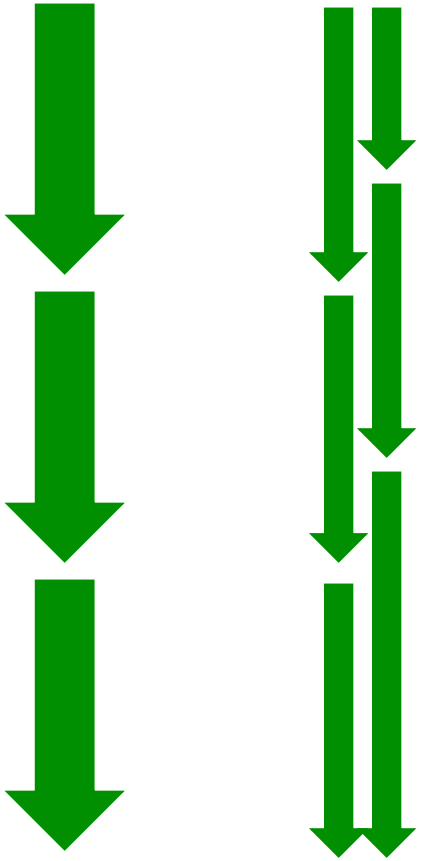
Global change and food webs

Landscape homogenization and synchrony

What is the effect of synchronous vs. asynchronous harvesting?

Simulated experiment for susceptible aphids

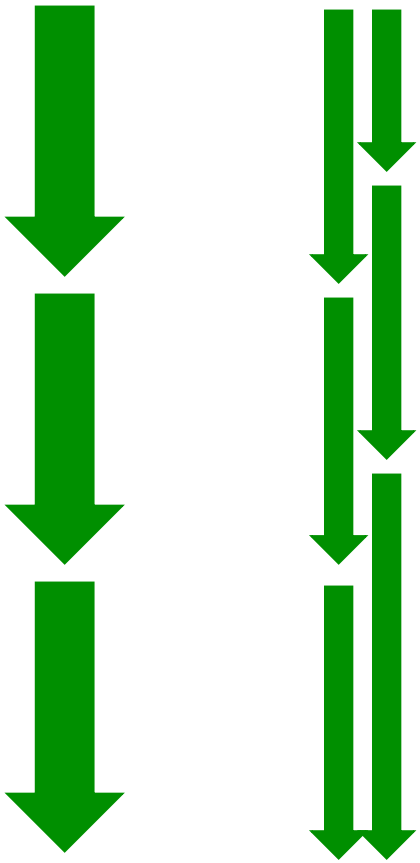


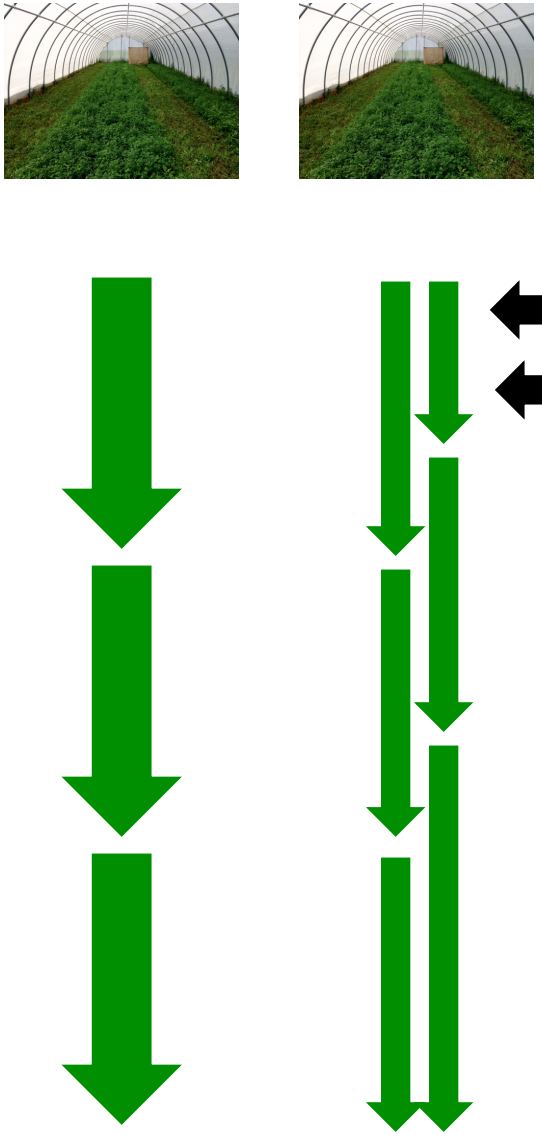


Experiment

Contrast synchronous vs. asynchronous harvesting

Augment natural populations with 50% resistant (*H. defensa*) and 50% susceptible clones

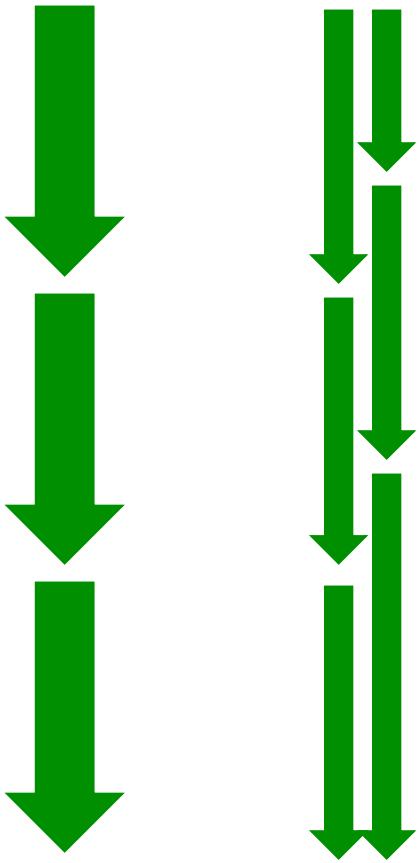


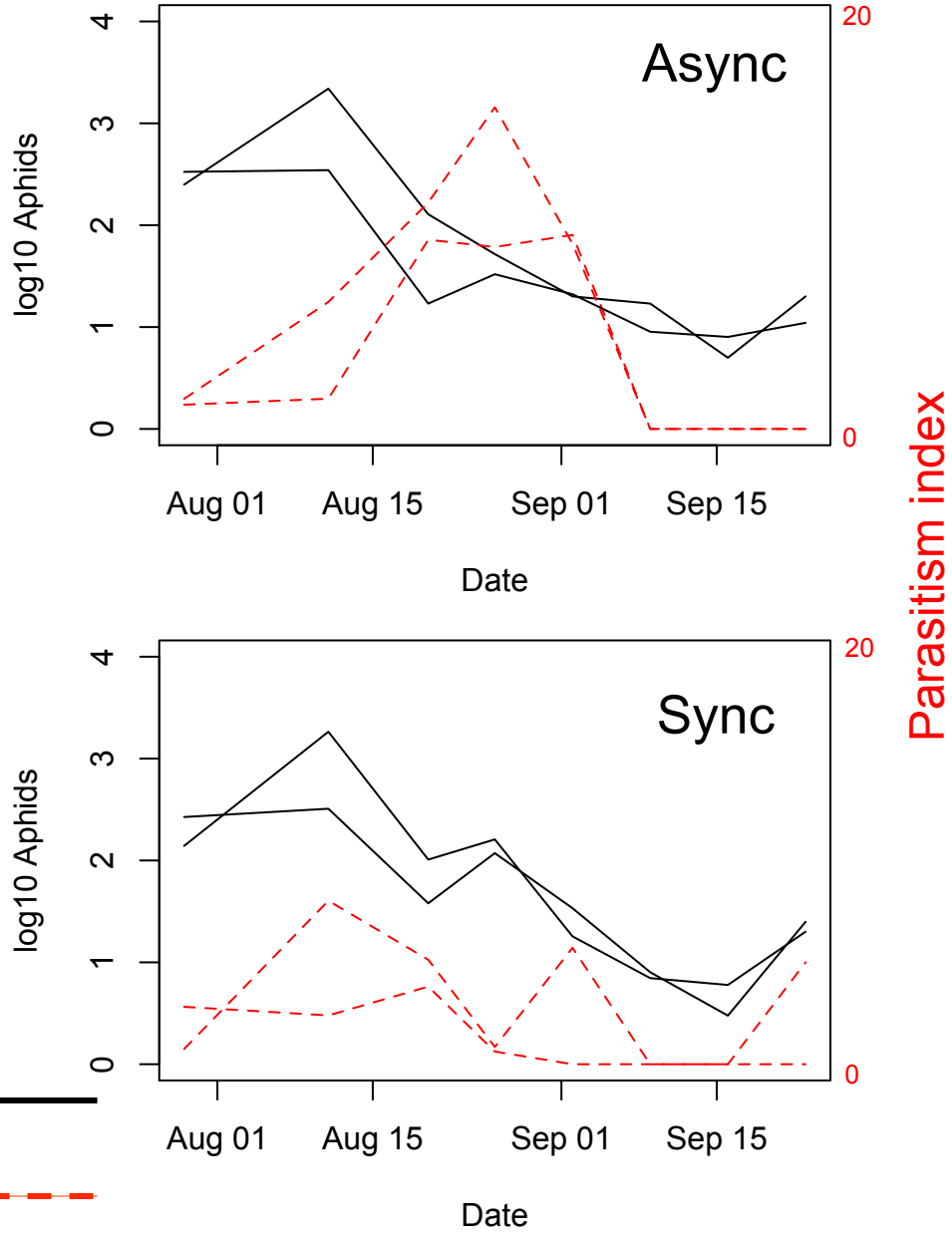


Augment natural populations of parasitoids to ensure at least moderate parasitism

Results: ecological dynamics



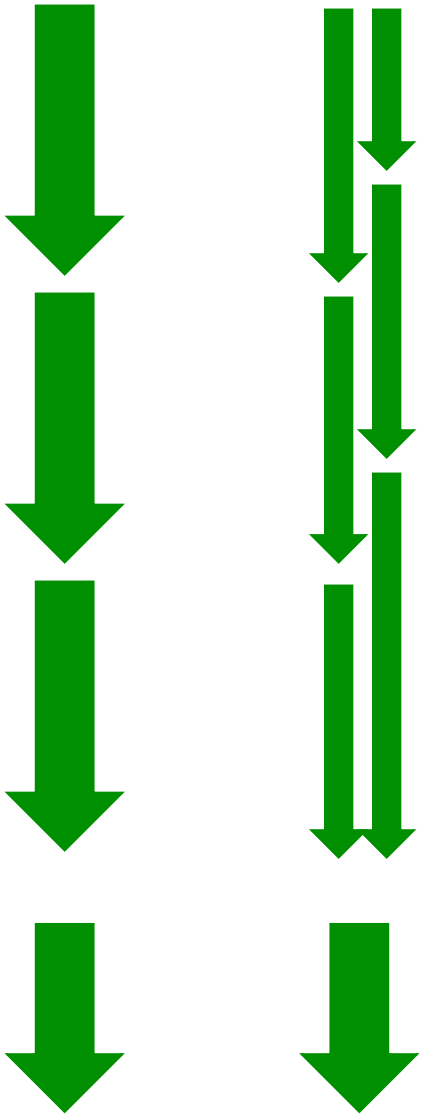





Results: evolutionary dynamics



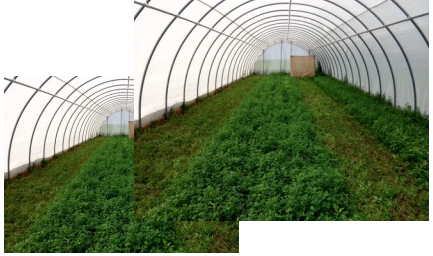

Treatment	Assayed	Resistant
async	100	50
async	101	63
sync	101	6
sync	100	7

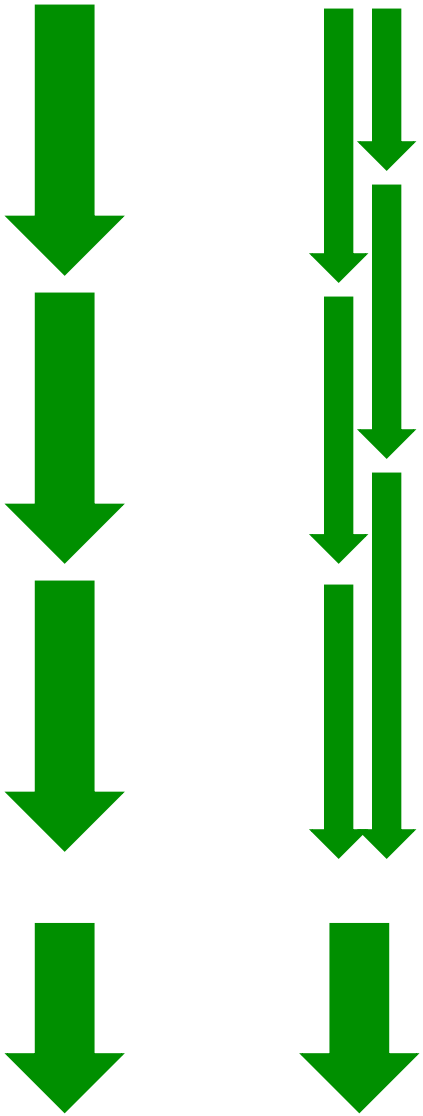


spatio-temporal variability

ecological dynamics

evolutionary dynamics





2015

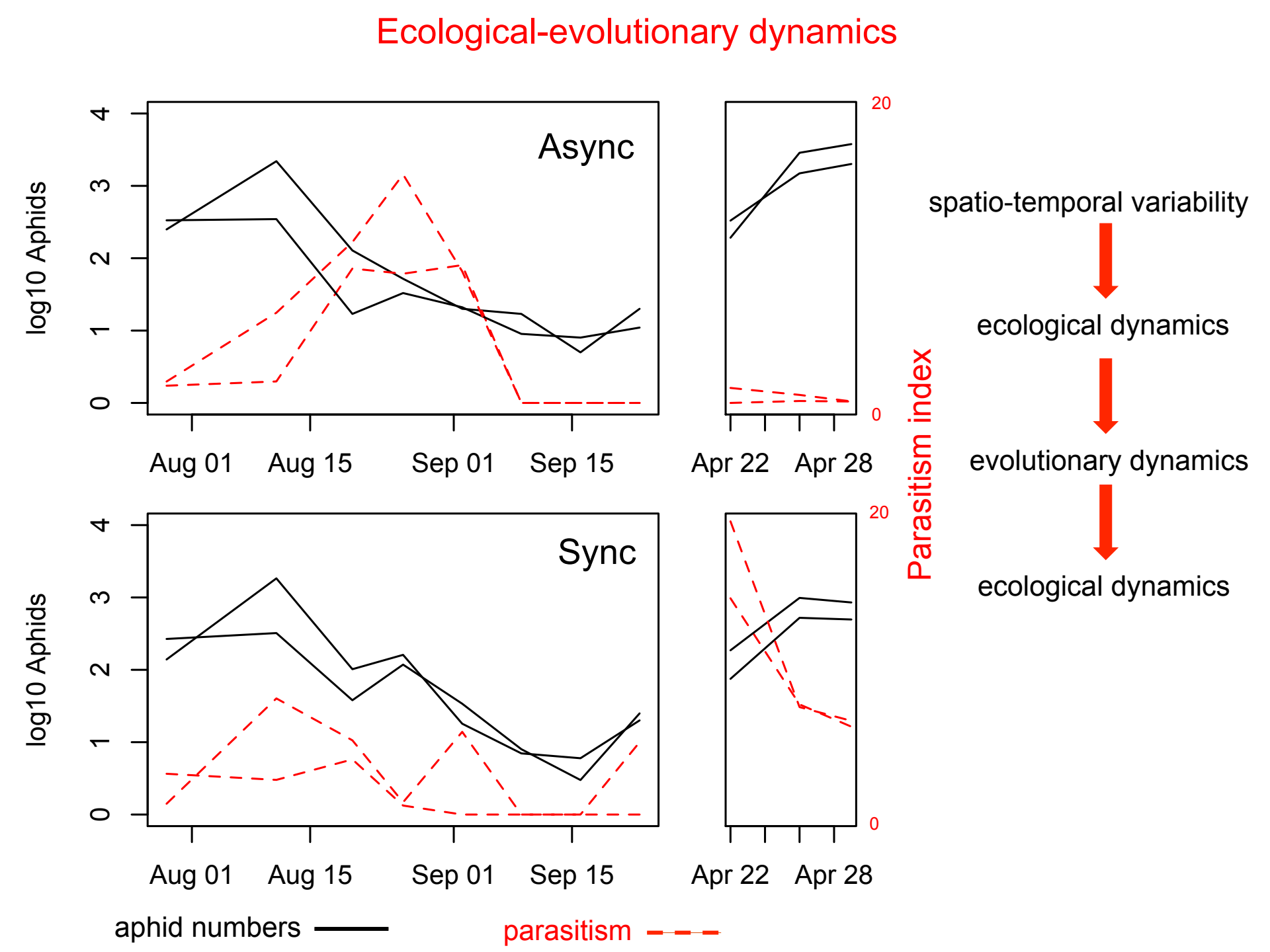
2016

spatio-temporal variability

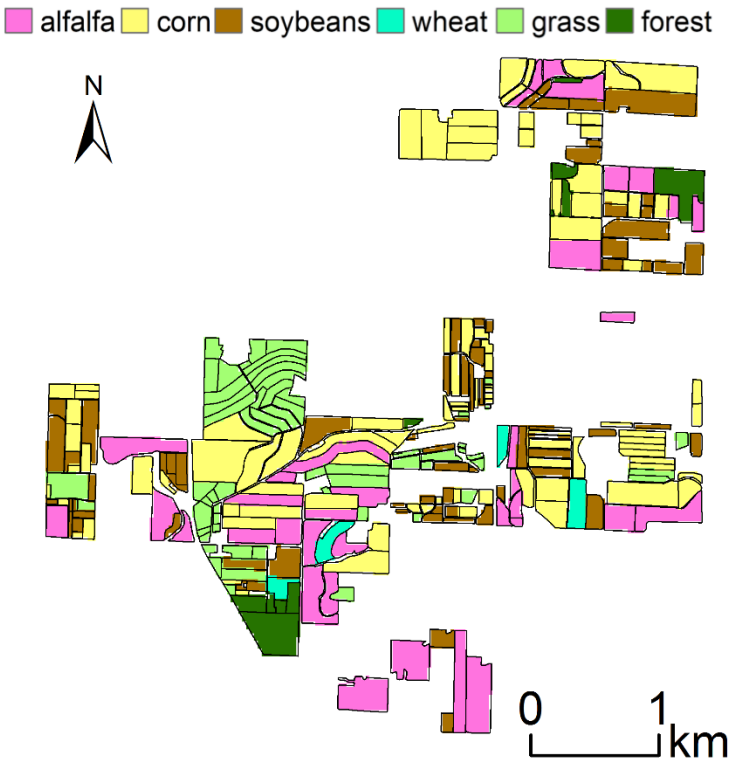
ecological dynamics

evolutionary dynamics

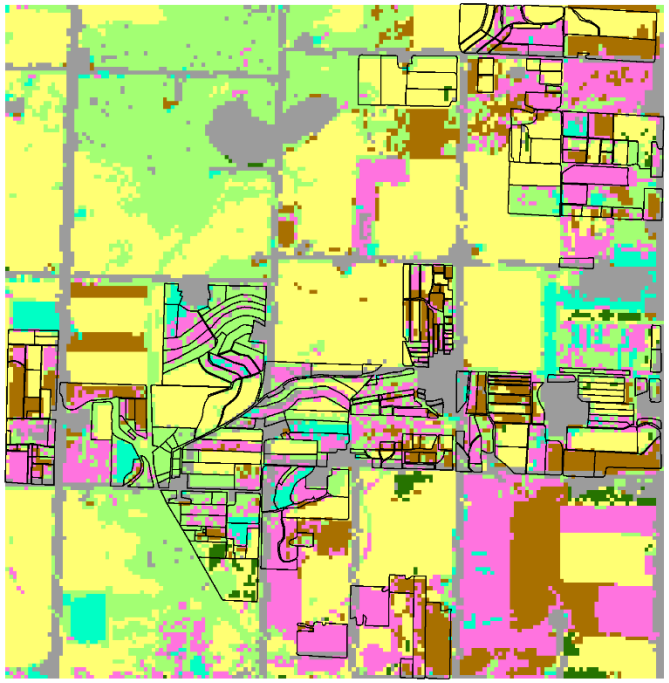
?


Ecological-evolutionary dynamics
Async
Sync
log10 Aphids
0
1
2
3
4
Aug 01
Aug 15
Sep 01
Sep 15
Apr 22
Apr 28
20
0
Parasitism index
spatio-temporal variability
ecological dynamics
evolutionary dynamics
ecological dynamics
aphid numbers
parasitism

Spatially diverse agricultural landscape

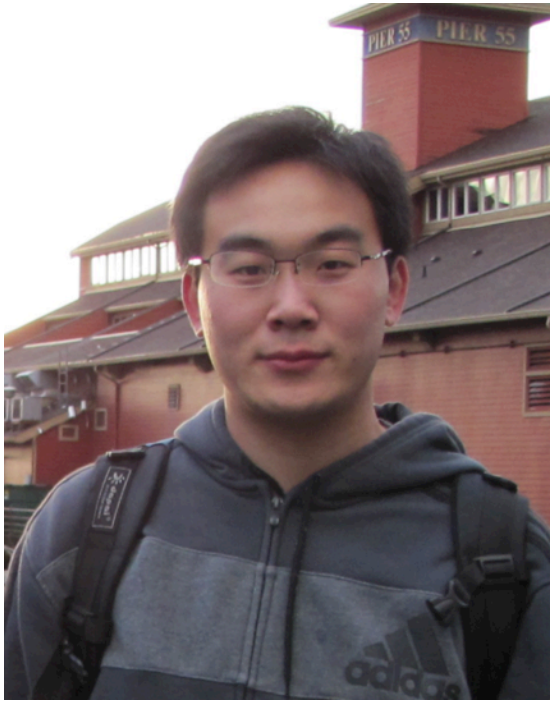


Arlington Research Station

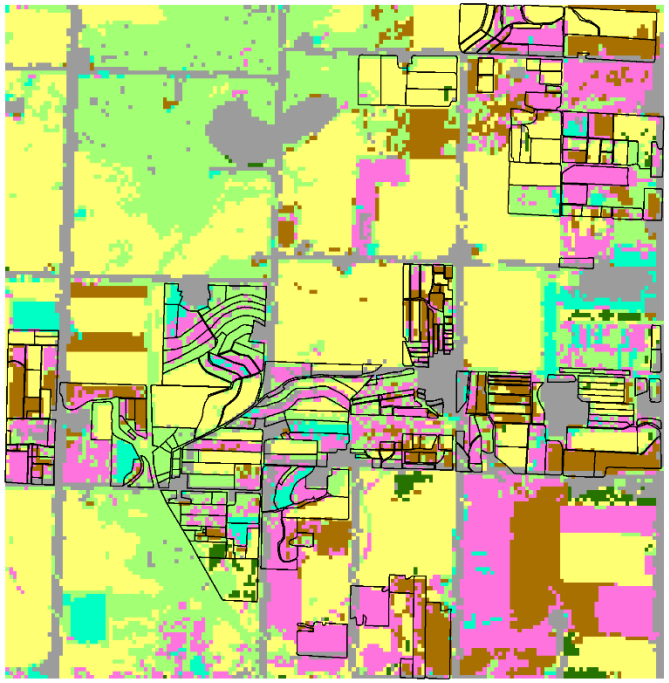


STARFM: Landsat + MODIS

Spatially diverse agricultural landscape

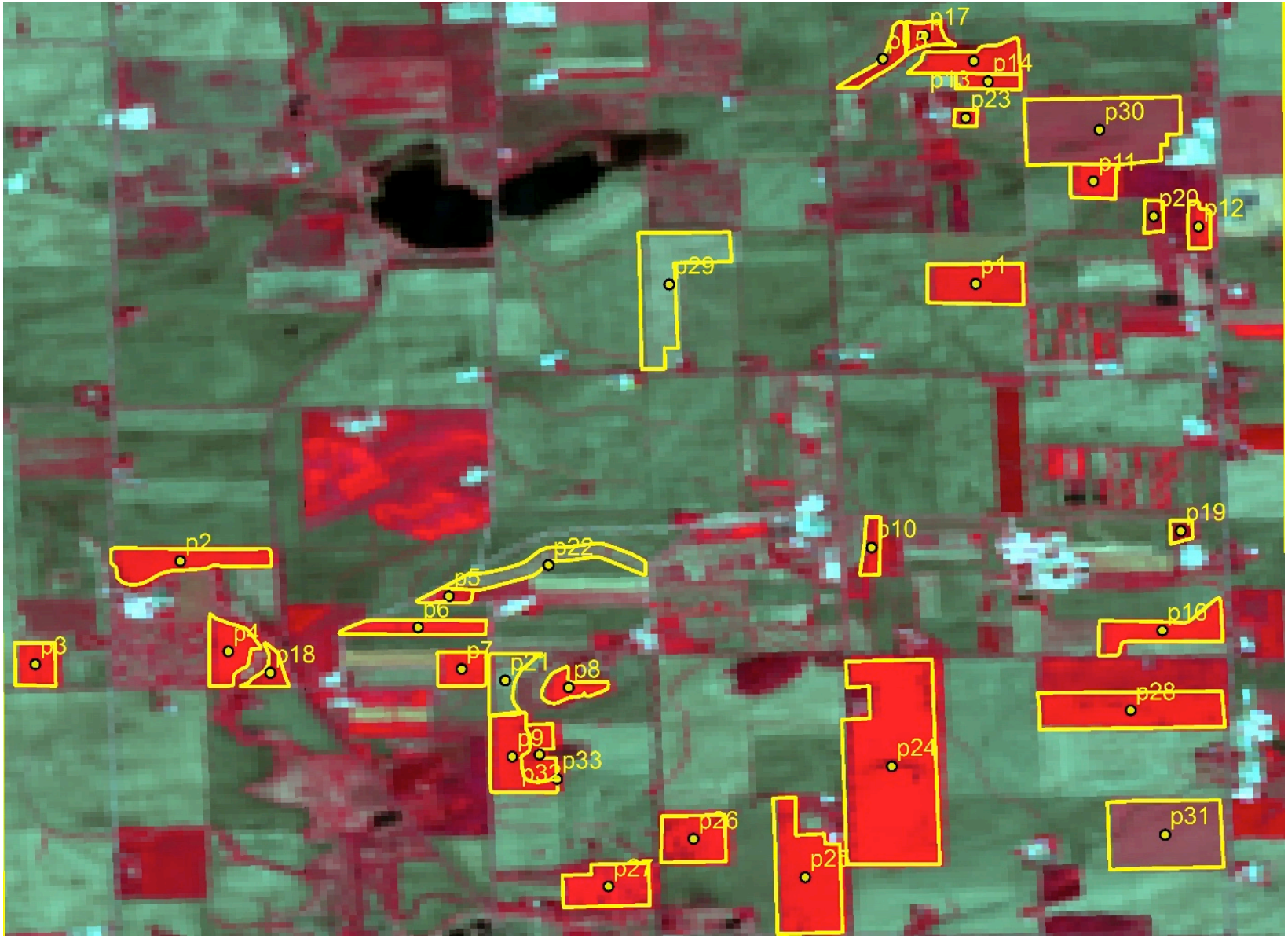


Likai Zhu

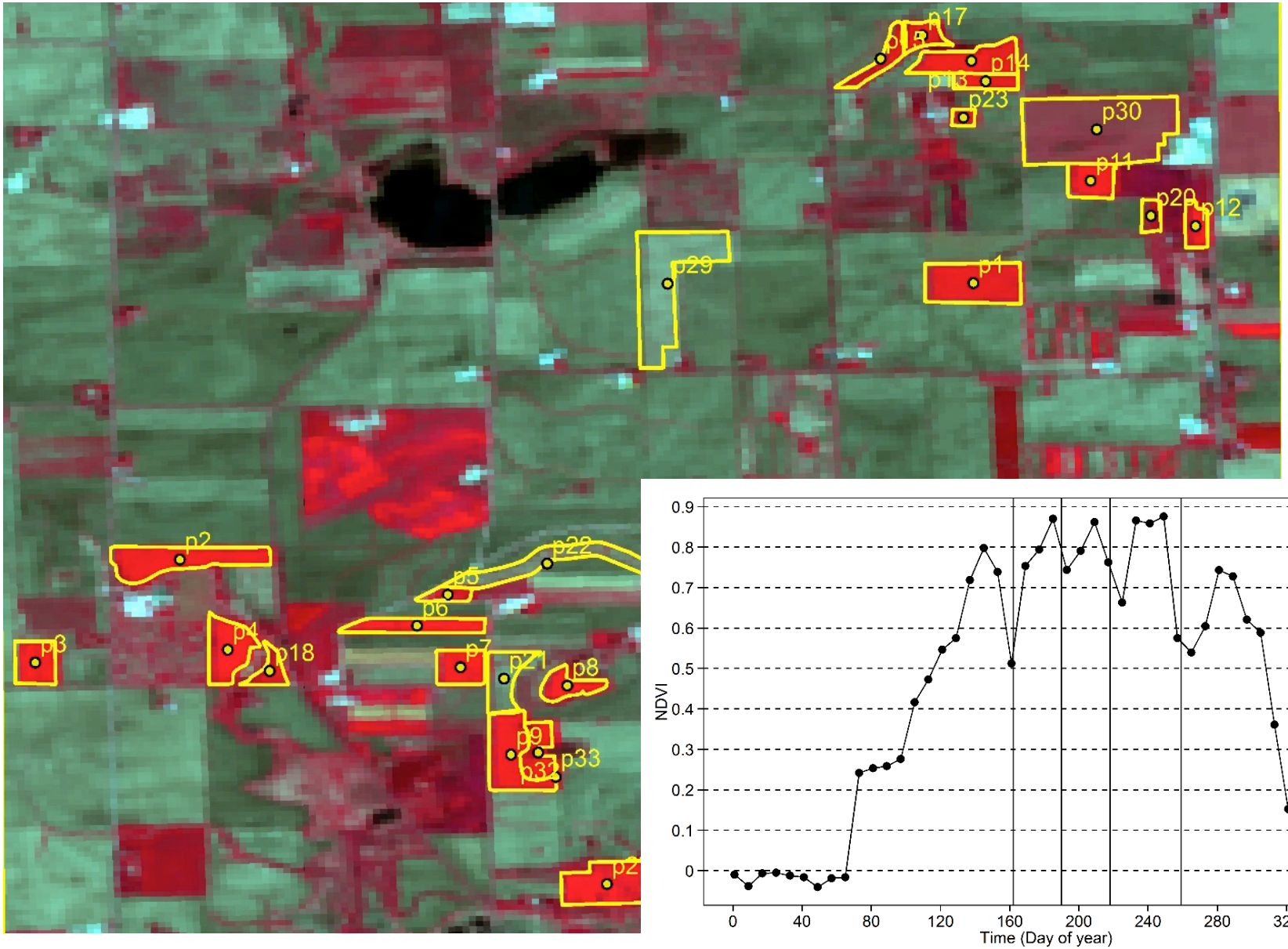


STARFM: Landsat + MODIS

Broad-scale view of disturbances



Broad-scale view of disturbances

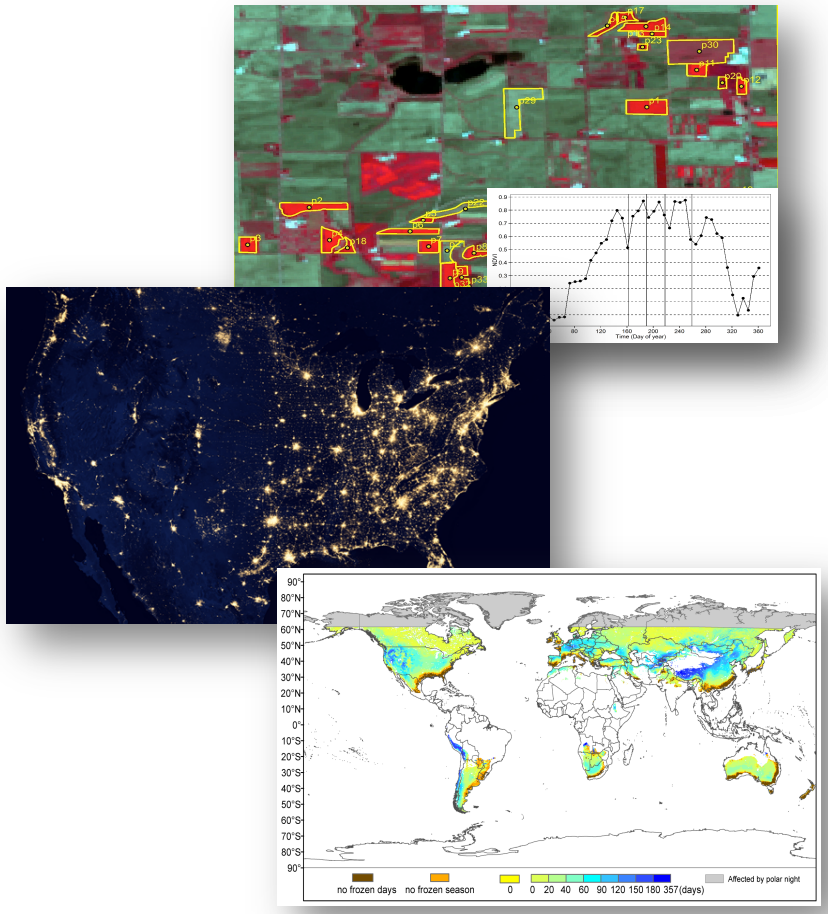


Global change and food webs

I. Landscape homogenization

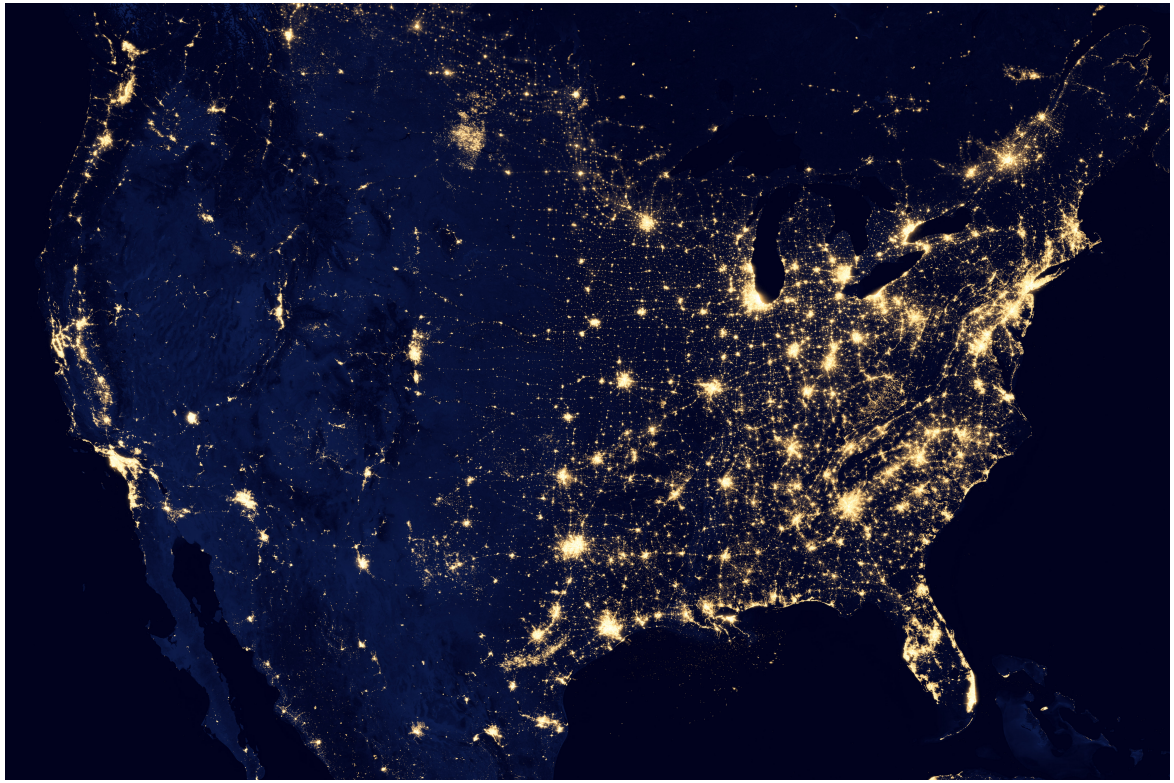
II. Nighttime lights and warming

III. Global warming in winter



Global change and food webs

Nighttime lights and warming



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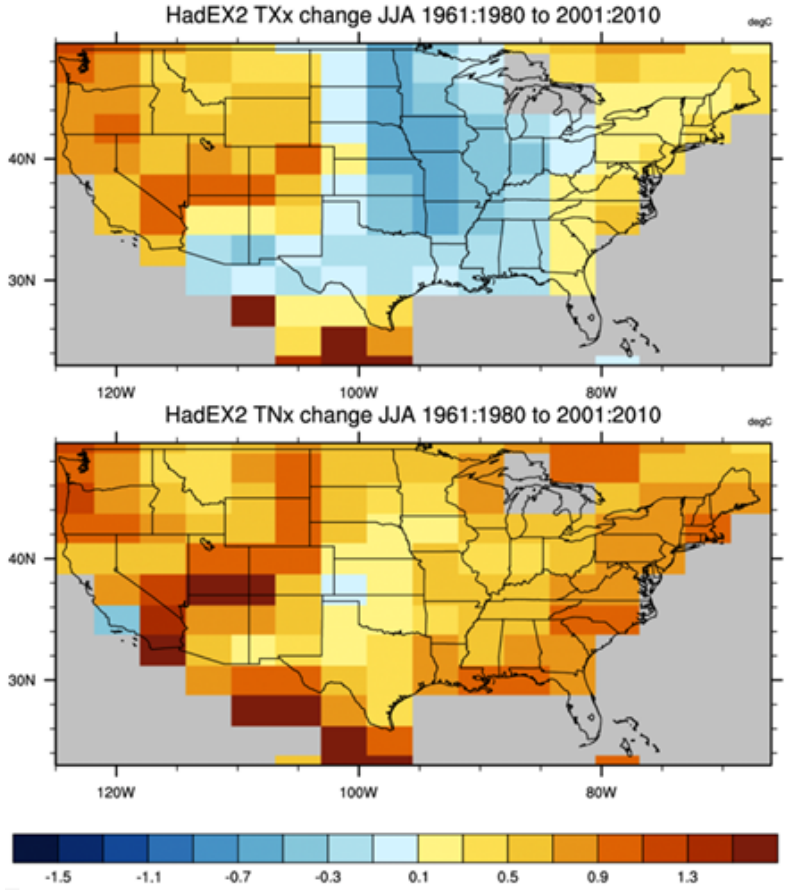
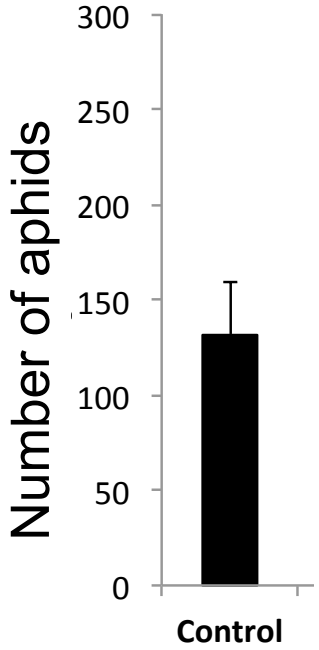
Nighttime lights and warming



C7
Visual hunter

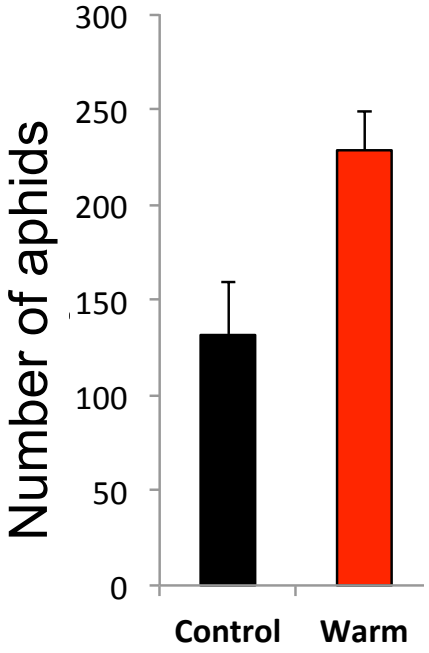
Cmac
Hunts in the dark

Visual predator



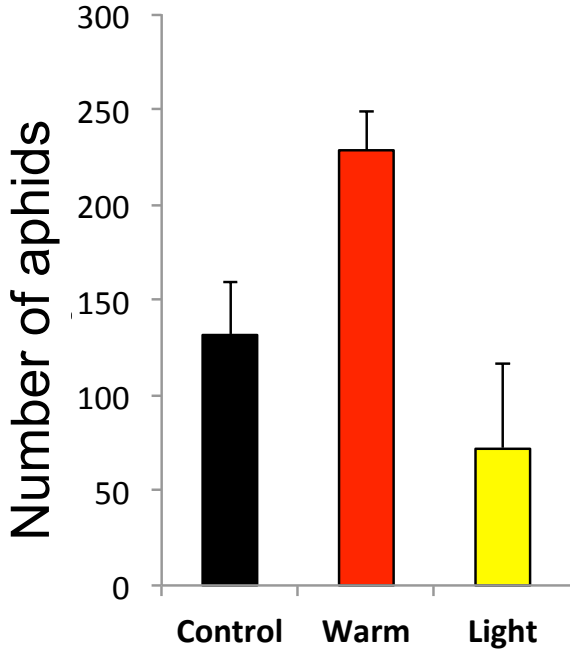
Visual predator

Night warming



Visual predator

Light pollution

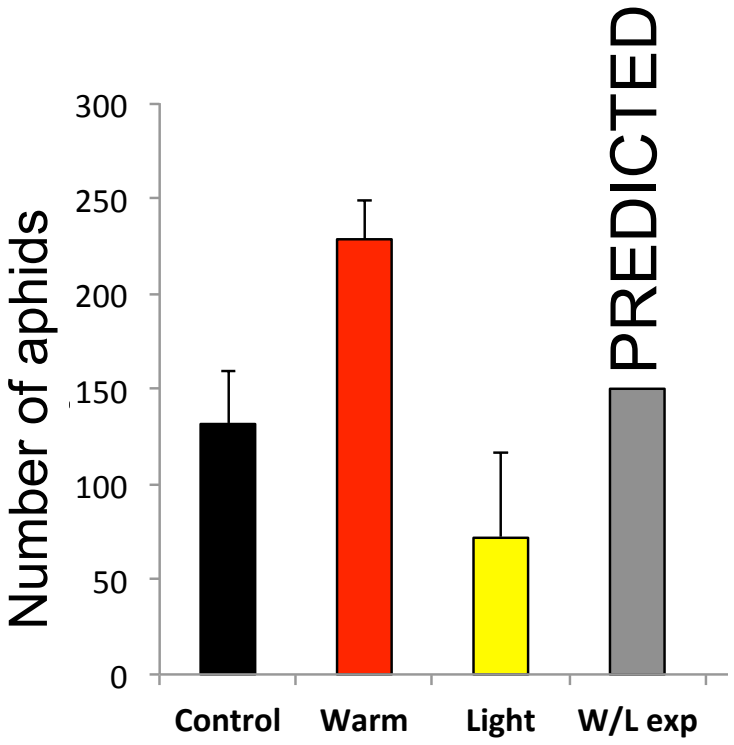


Visual predator

Night warming

Light pollution

PREDICTED



Visual predator

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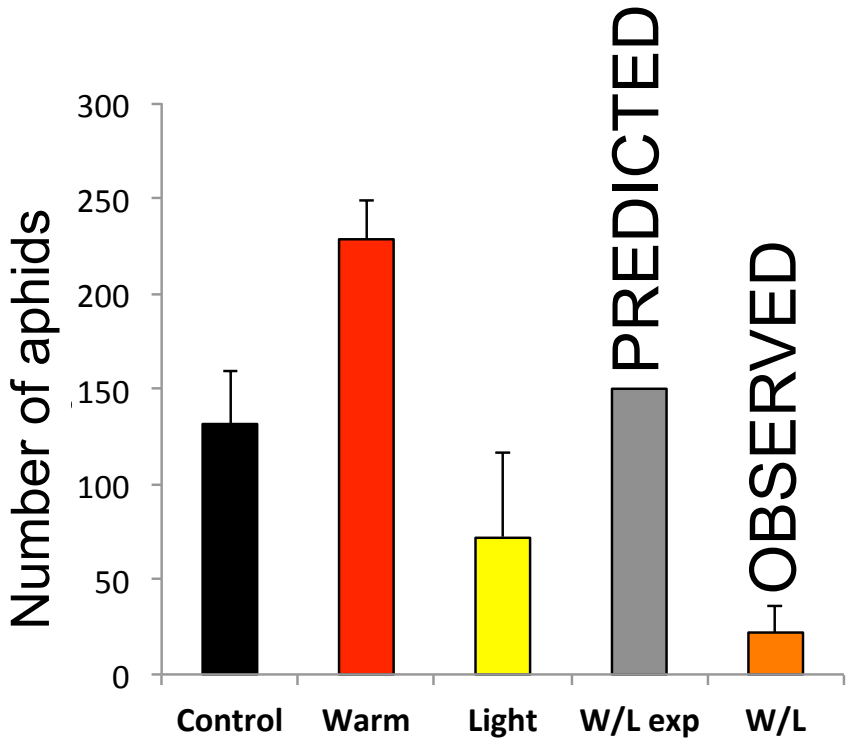

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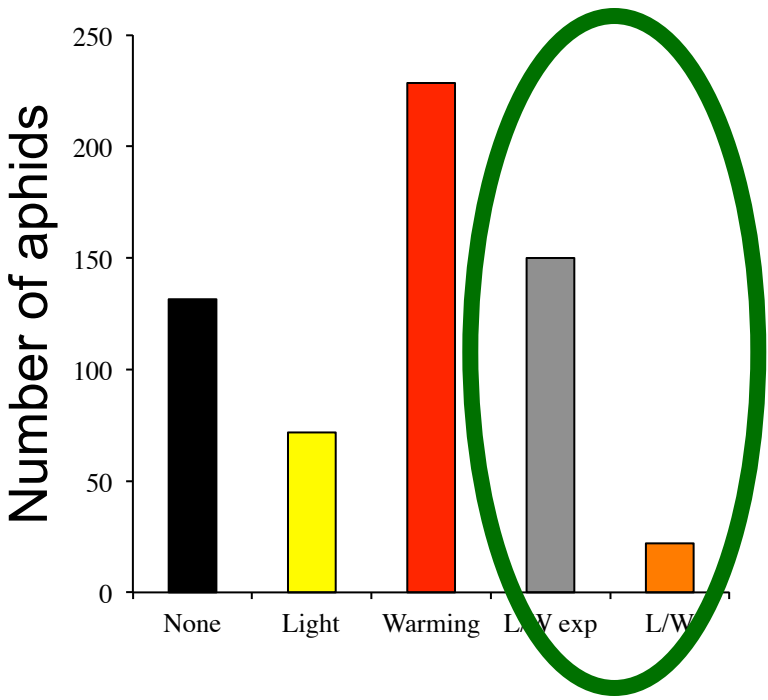
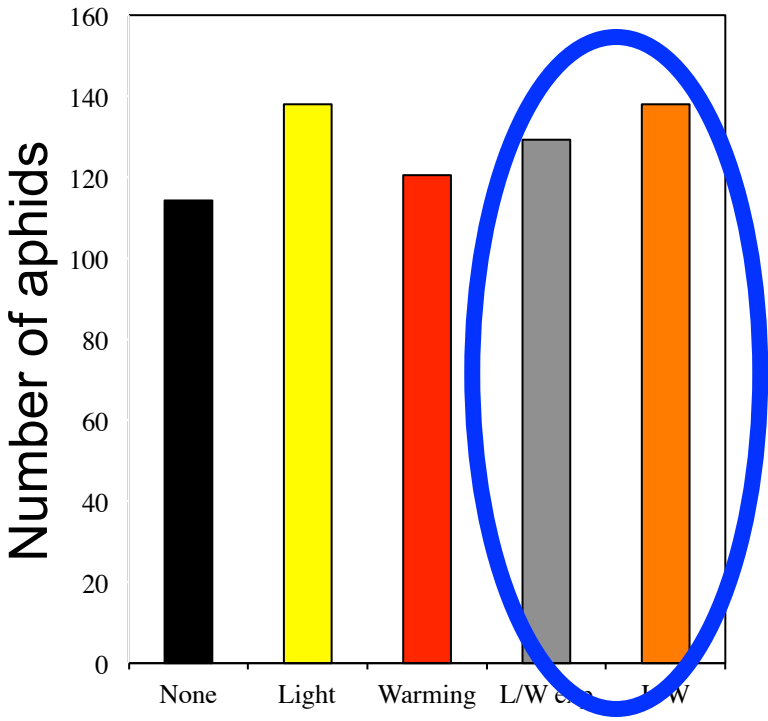
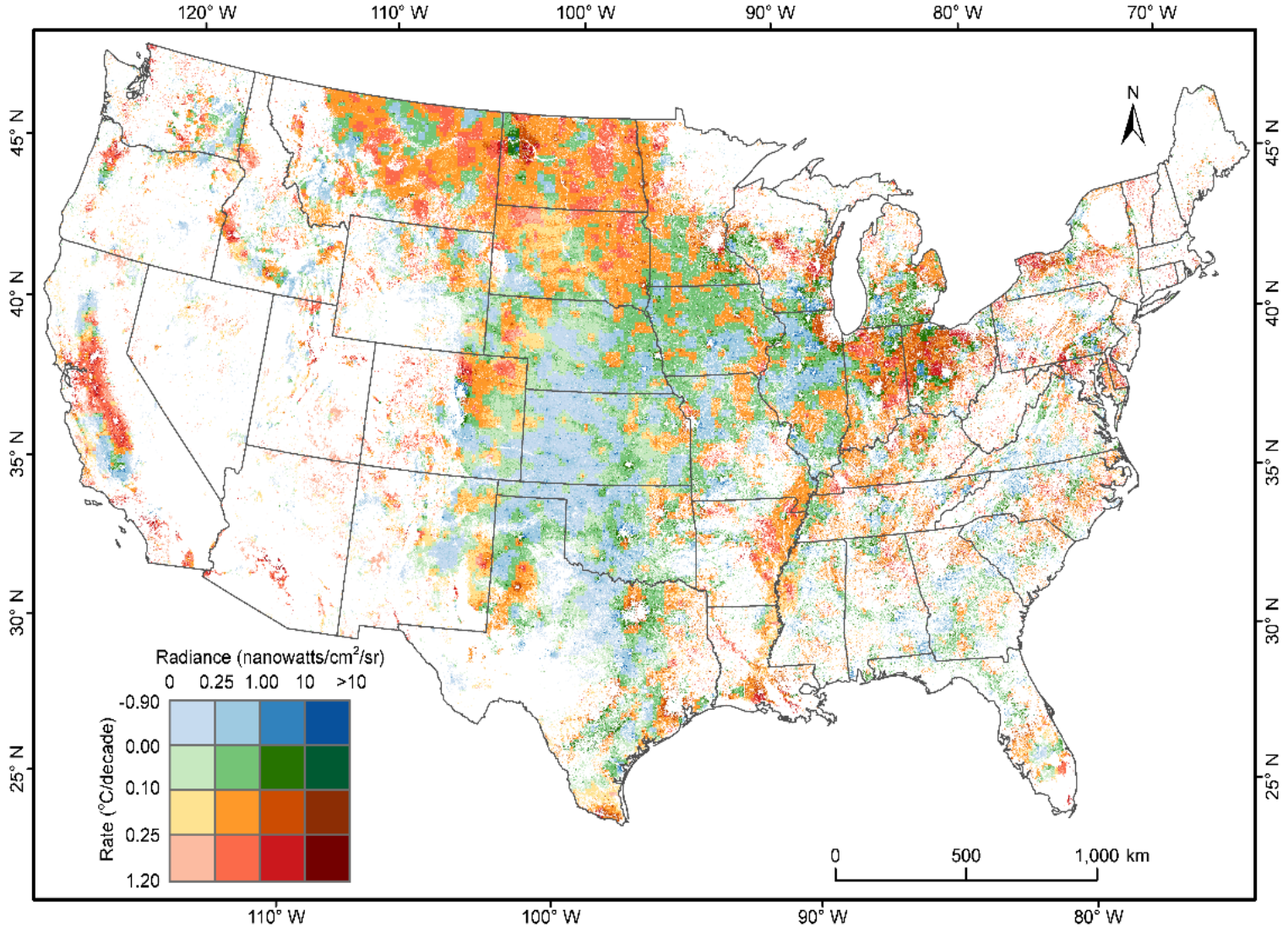




Nighttime lights vs. nighttime warming in US croplands



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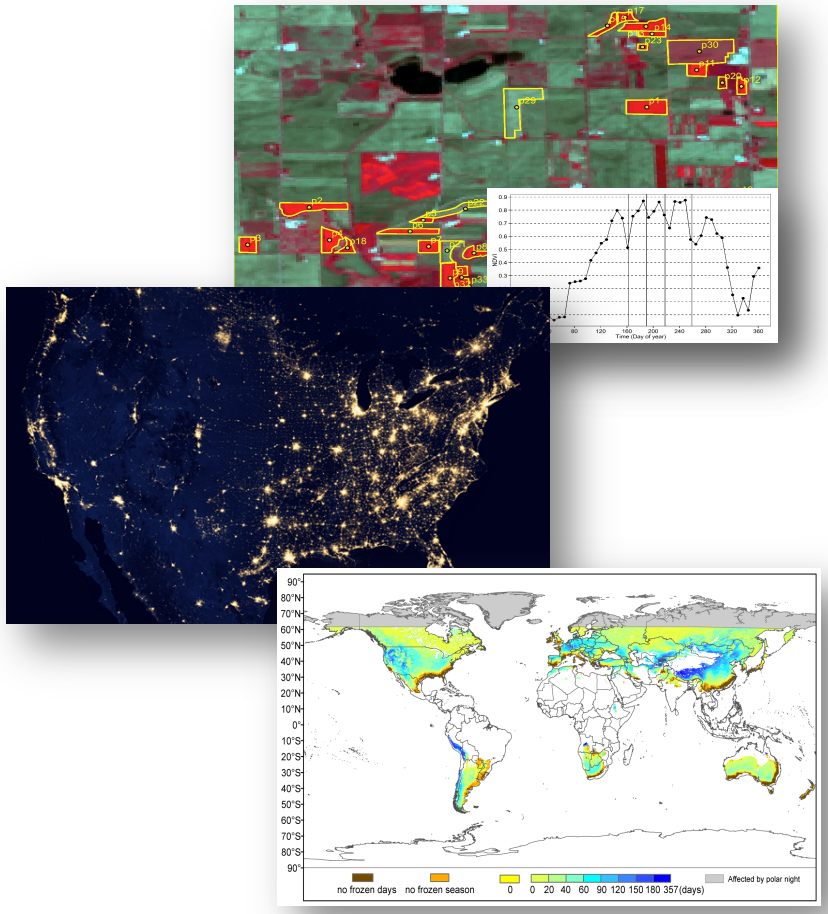
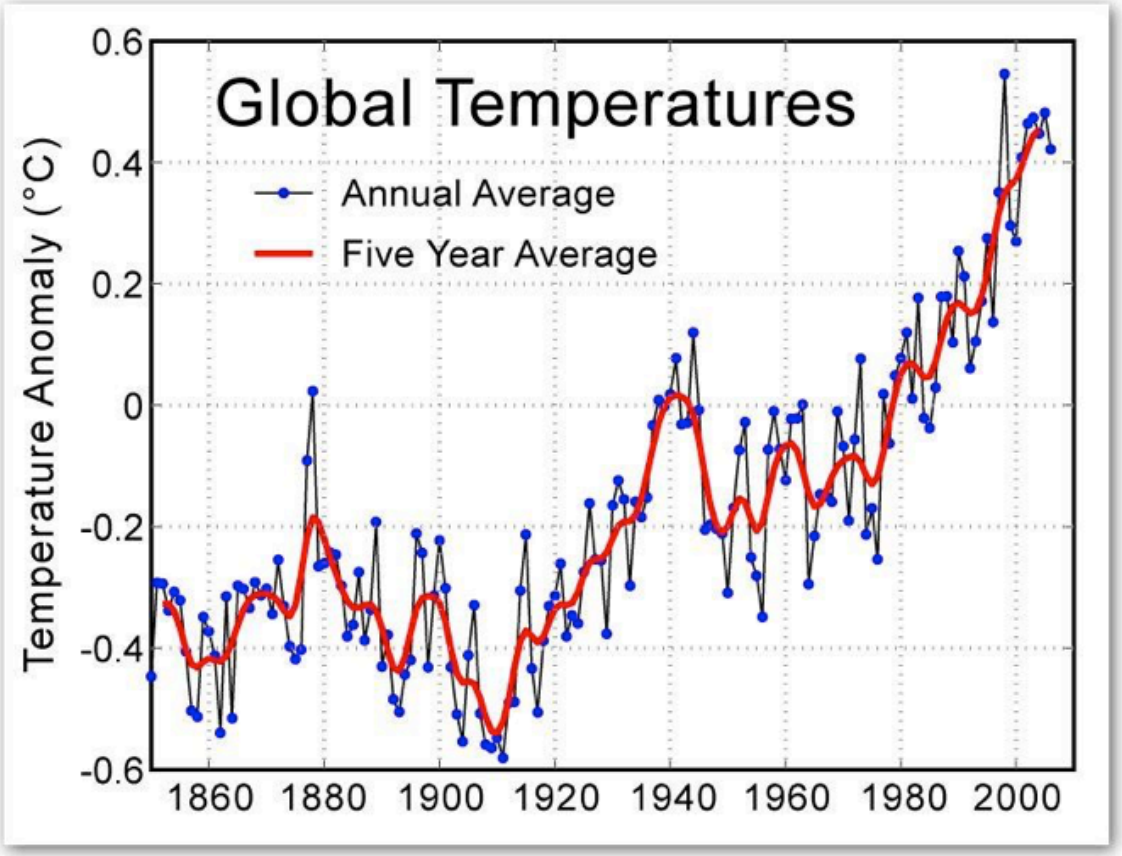
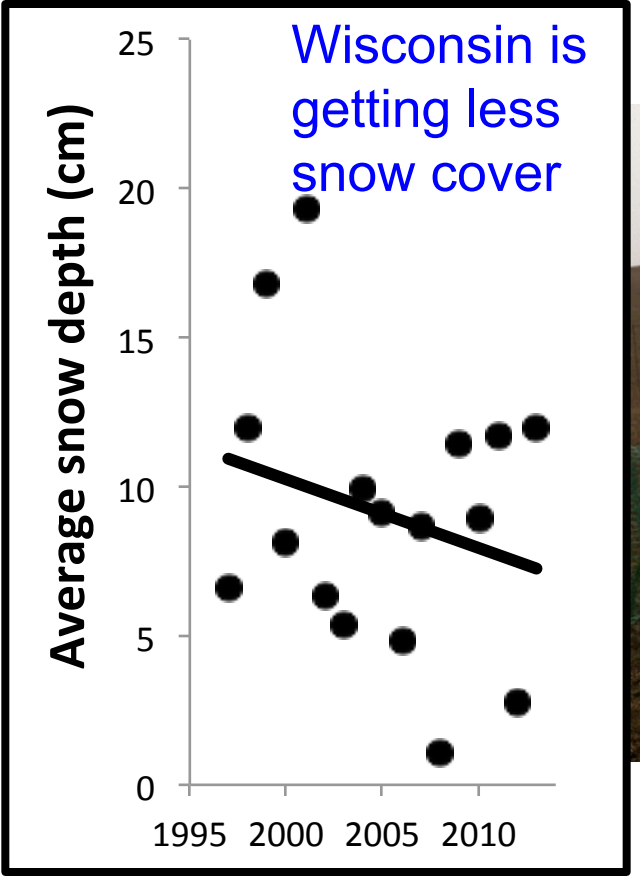
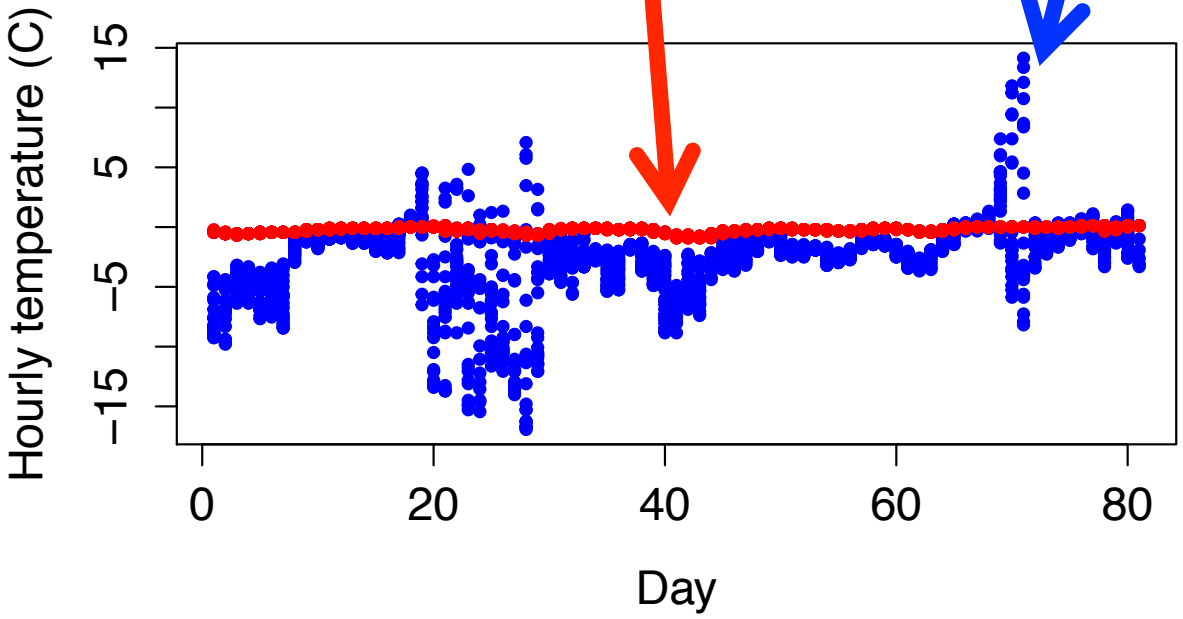


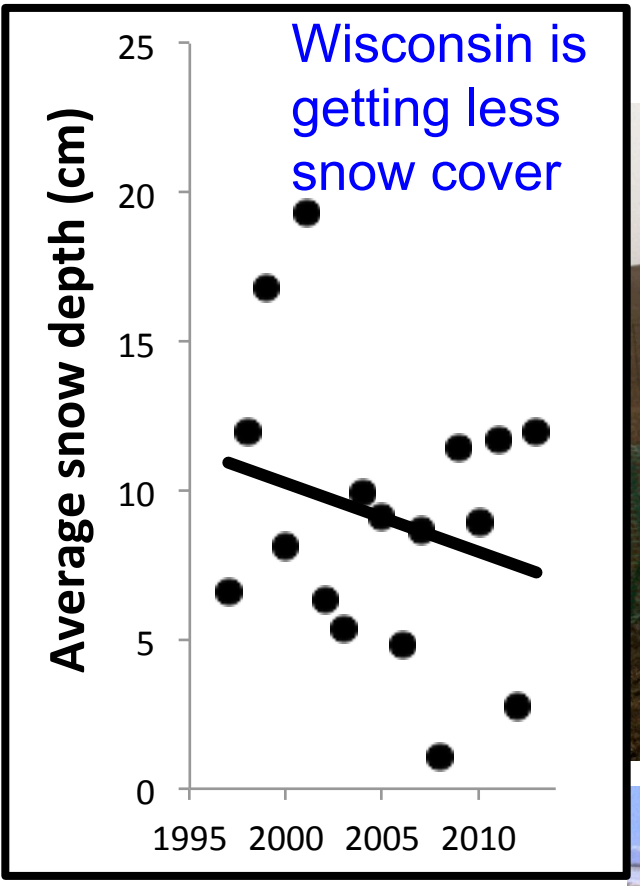
Global change and food webs

Winter warming

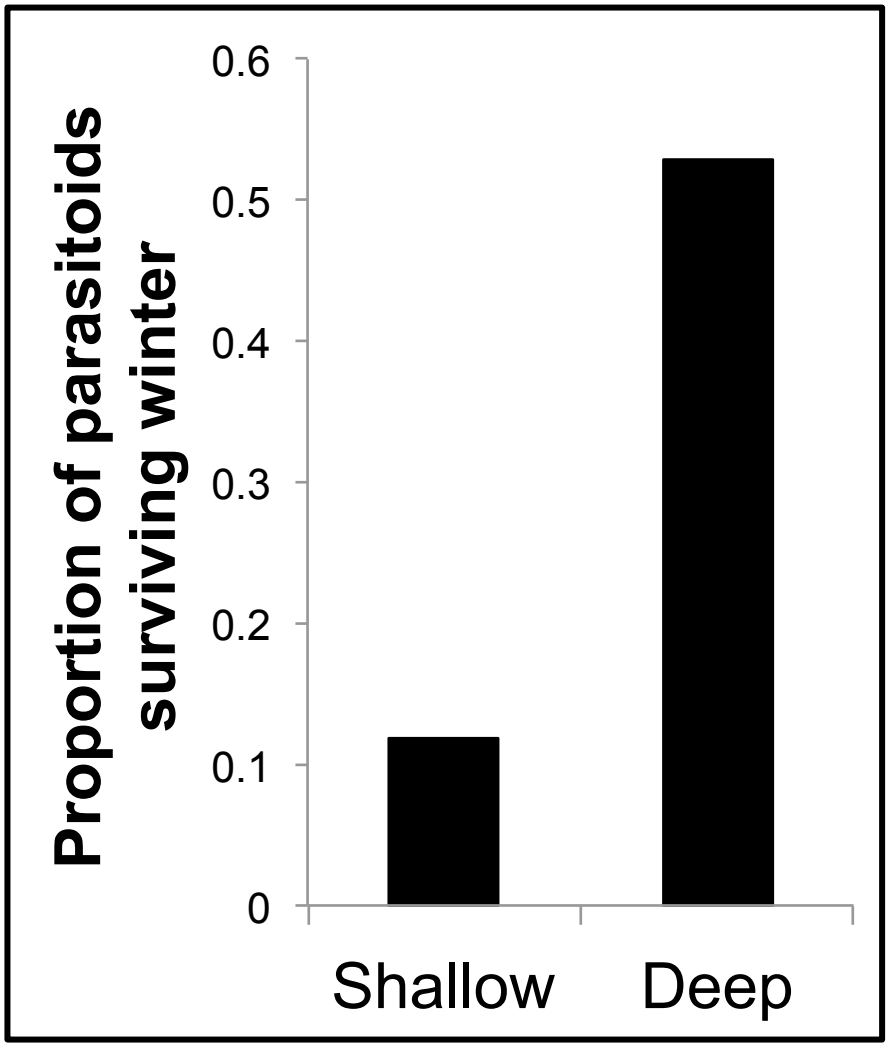


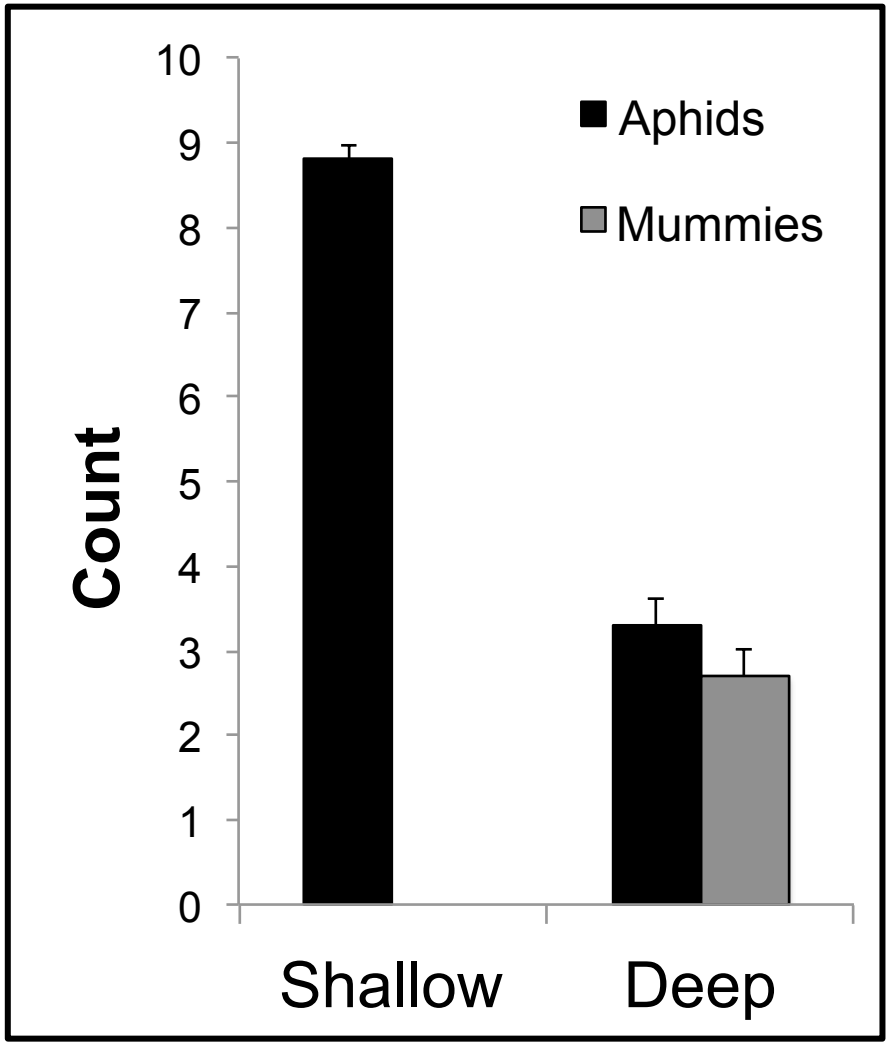

Wisconsin is getting less snow cover
Average snow depth (cm)
25
20
15
10
5
0
1995
2000
2005
2010


Hourly temperature (C)
15
5
−5
−15
0
20
40
60
80
Day

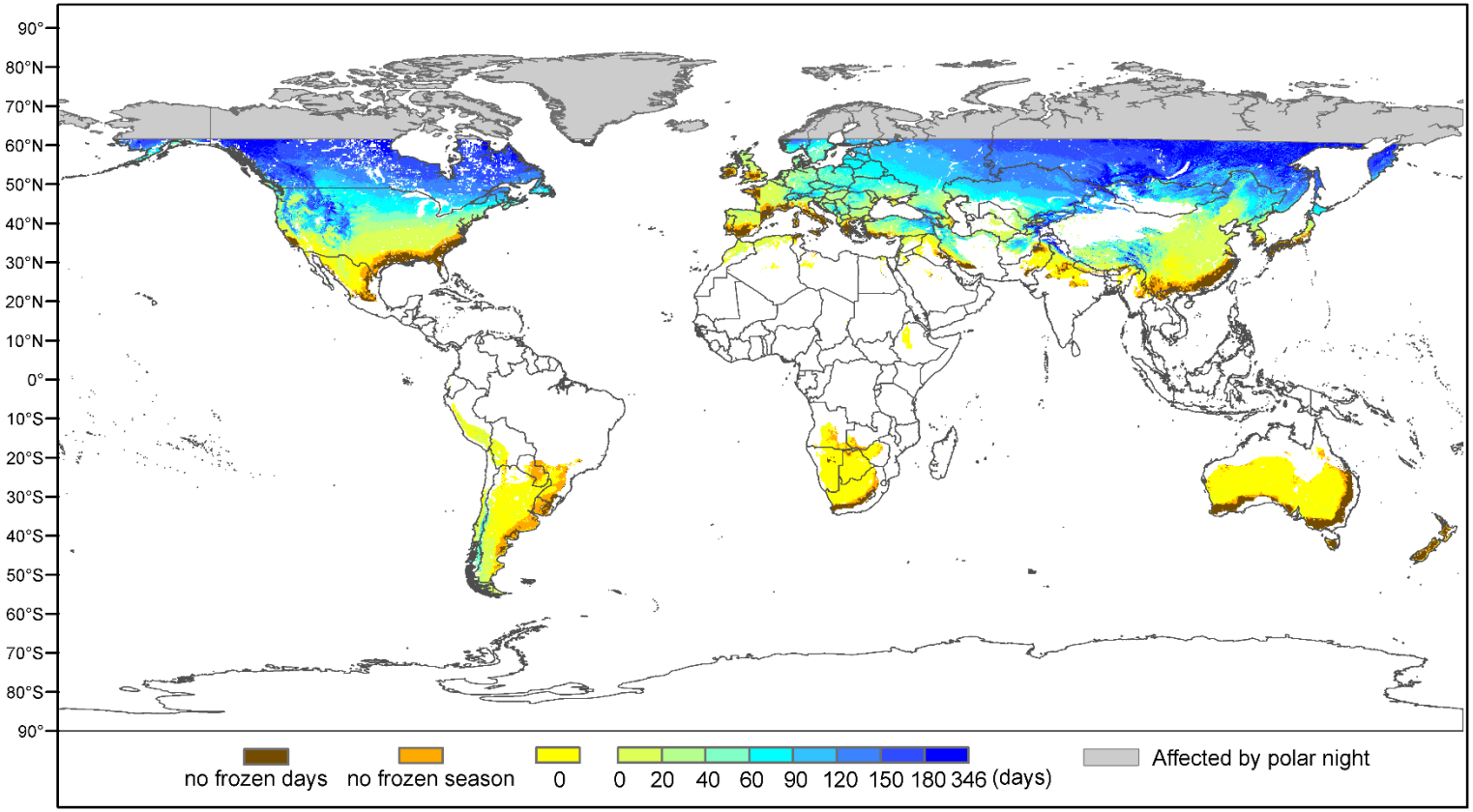

Wisconsin is getting less snow cover
Average snow depth (cm)
25
20
15
10
5
0
1995
2000
2005
2010

Less snow reduces parasitism and increases aphid density

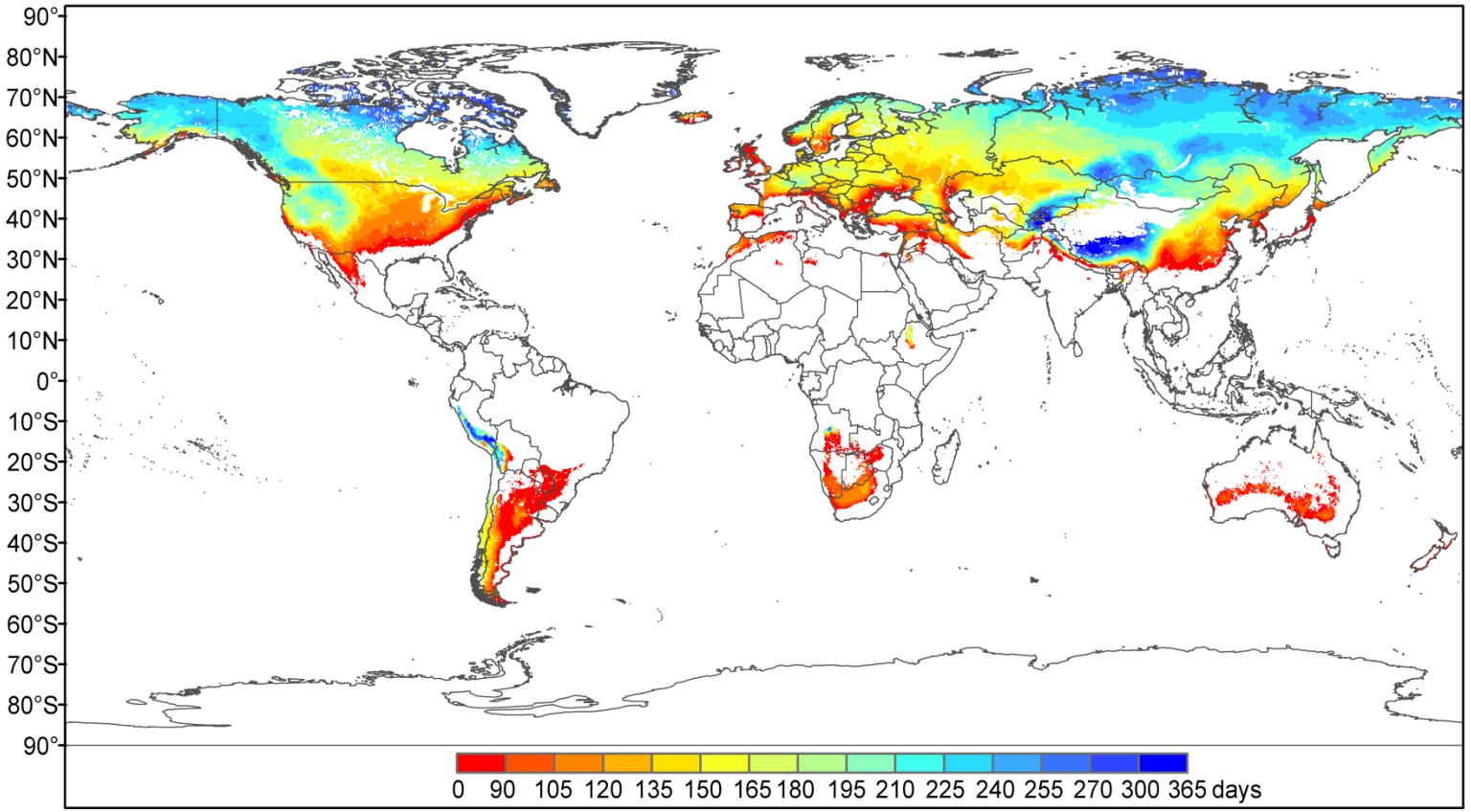




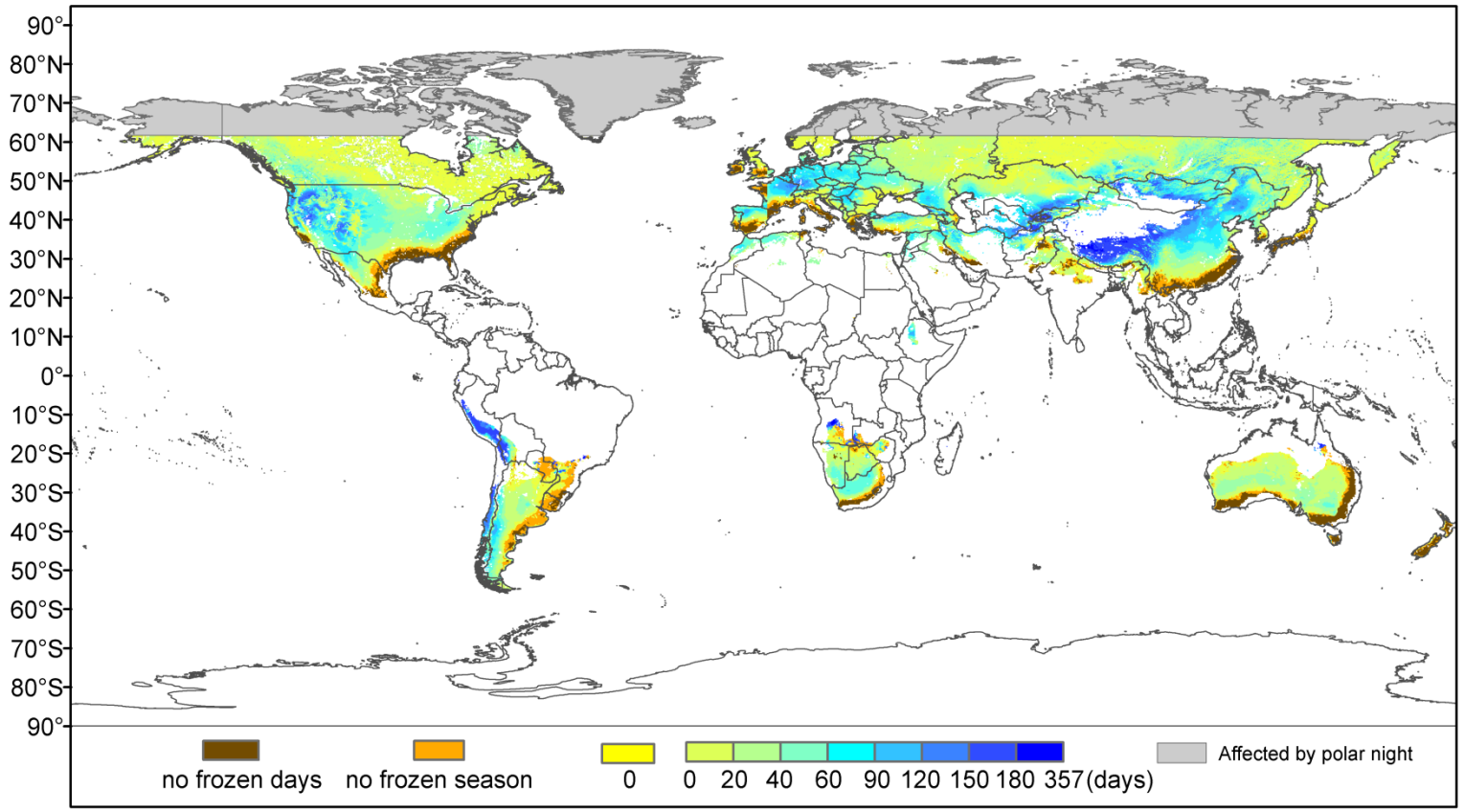
Snow cover (MODIS)



Frozen ground (AMSR-E)



Frozen ground with no snow



Characterizing global patterns of frozen ground with and without snow cover with AMSR-E and MODIS satellite data products

SILVIS Lab
Spatial Analysis for Conservation and Sustainability

Likai Zhu[1], Volker C. Radeloff[1], and Anthony R. Ives[2]
[1]SILVIS Lab, Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, USA; [2]Department of Zoology, University of Wisconsin-Madison, USA

Introduction

- Whether frozen ground is covered by snow greatly affects biotic responses to climate change because the subnivium can provide an insulated and thermally stable refugium
- Satellite data characterizing of freeze/thaw cycles and snow cover are available, but have not been combined to map the subnivium

Goal

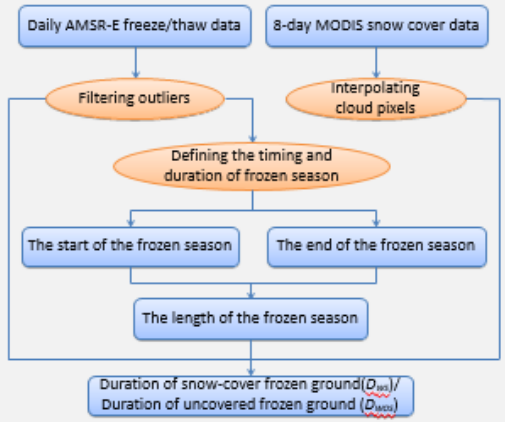
To characterize global patterns of frozen ground with or without snow in order to provide a baseline to assess the effects of future winter climate change on organisms that overwinter

Data and methods

Data

- NASA MEaSUREs Global Record of Daily Landscape Freeze/Thaw Status data from AMSR-E: 2000-'12
- 8-day MODIS Snow Cover product (MOD10A2) from 2000-'12

Methods



The start of the frozen season: the middle day of the first 15 consecutive days for which at least 8 days were frozen
The end of the frozen season: the middle day the last 15 consecutive days for which at least 8 days were thawed
The length of the frozen season: the period between the start and end of the frozen season

Global patterns of D_{ws} and D_{wos}

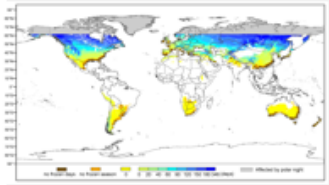


Fig. 1 Global pattern of the mean length of the snow season (D_{ws}, 2000-'12). The Northern Hemisphere accounted for about 97% of all snow covered ground. The longest D_{ws} occurred in mountainous regions and high latitudes.

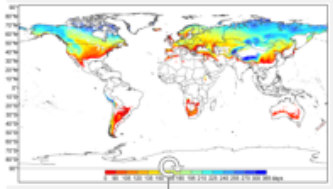


Fig. 2 Global pattern of the mean length of the frozen season (2000-'12). The pattern was similar to that of the D_{ws}, which indicated that the D_{ws} became longer with an increase in the frozen season duration.

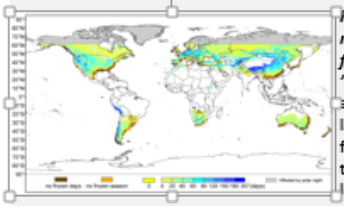


Fig. 3 Global pattern of the mean length of uncovered frozen ground (D_{wos}, 2000-'12). Cold constrained areas were at middle latitudes even though the frozen season was shorter there than that at high latitudes.

We calculated the mean D_{ws} and D_{wos} in one-degree bins of latitude. D_{ws} increased with latitudes (Fig. 4a). D_{ws} was shorter in Europe than that in Northern America and Asia. In the Northern Hemisphere, the D_{wos} peaked at about 35 °N (Fig. 4b)

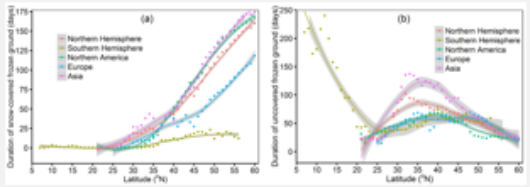


Fig. 4 Variations of (a) D_{ws} and (b) D_{wos} by latitude. We smoothed the data with a local polynomial regression fit.

Global pattern of D_{ws} percentage

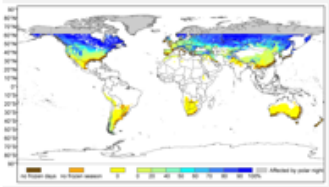


Fig. 5 Global pattern of the percentage of D_{ws} (D_{ws} divided by the sum of D_{ws} and D_{wos}). The longest D_{ws} mainly occurred at the mountainous regions and high latitudes.

Temporal variability of D_{ws} and D_{wos}

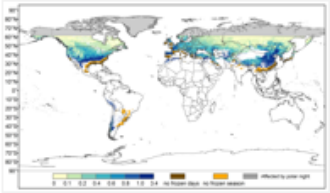


Fig. 6 Global pattern of the coefficient of variation (CV) of D_{ws}. The temporal variability of D_{ws} was lower at higher latitudes.

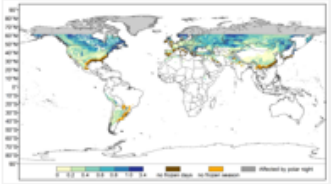


Fig. 7 Global pattern of the CV of D_{wos}. The temporal variability of D_{wos} was greater at higher latitudes.

Discussion and conclusions

- We developed a 500-m resolution dataset for 2000-'12 that captured global patterns of snow-covered and uncovered frozen ground
- The mid-latitude areas were functionally colder than either northern or southern latitudes due to more days of uncovered frozen ground
- The D_{wos} at high latitudes may be more sensitive to climate change because of its shorter duration and greater temporal variability
- Climate warming may result in a counterintuitive trend of large areas in the north becoming functionally colder as snow cover diminishes

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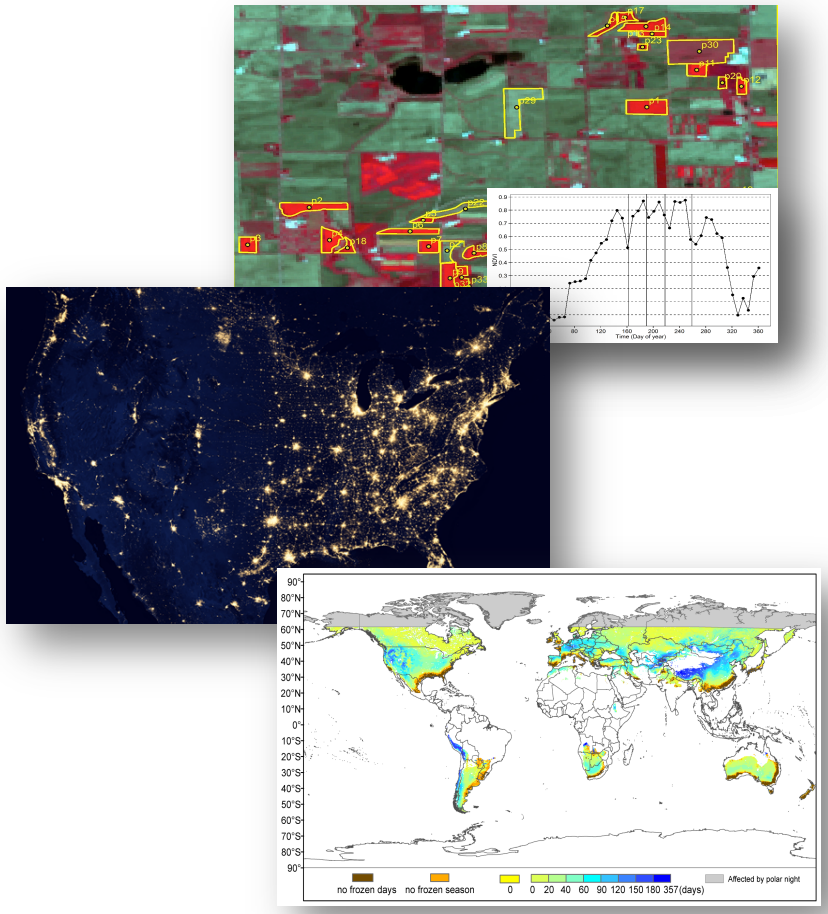
Global change and food webs

I. Landscape homogenization

II. Nighttime lights and warming

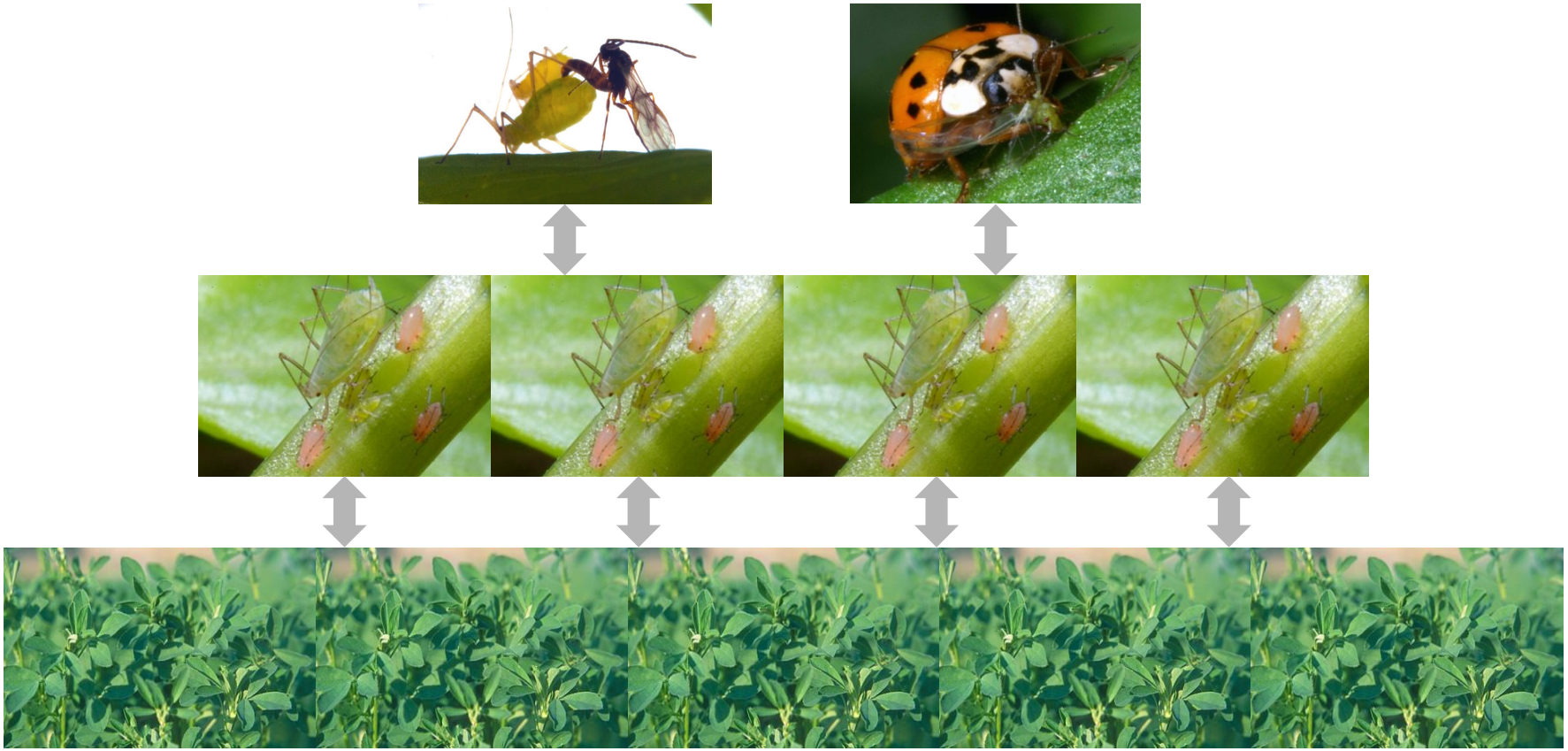
III. Global warming in winter



Global change and food webs

I. Homogenization and synchronous mowing disrupts predator-prey cycles, and evolutionary dynamics
II. Interaction of nighttime lights and warming gives visual predators an unpredicted edge
III. Winter warming makes mid-latitudes functionally colder, preventing the overwintering of parasitoids wasps

Global change and food webs



Global change and food webs

Global change and food webs

Loose scaling between experiments and satellite data can be both fruitful and fun!


Thank
you!